NETWORKS DIVISION

CODE 530

Guam Alternatives Study

Options for Installation of a TDRS Ground Terminal at Guam

Tom Gitlin
May 16, 1996

Study Goals and Constraints

- The primary study goal was to identify various ground systems that could be installed at Guam to support TDRS and TDRS customers
- Driving study constraints†:
  - Implementation cost less than $30M.
  - Implementation schedule less than 24 months.
  - Life cycle costs tolerable (staffing, sparing, logistics).
  - Any risks to TDRS health and welfare tolerable (no objective criteria set; approaches judged inherently “safe” or “unacceptable”).
  - Reliability similar to WSC (>99%).
  - Mission safety (reliability, availability) acceptable.

† - Although the cost and schedule constraints are significant, options that included estimates that exceeded the constraints were still explored, and the results will be presented.

Study Assumptions

- Assumptions†:
  - System capable of continuous (24 x 7) operation.
  - TDRS communication via an 11-m dual band antenna
    - Communication margins with this type of antenna system are predicted to support high rate customer data under favorable conditions (i.e. minimal/no rain).
  - System to support S- and K-band customers (including Shuttle).
  - System to be installed at the Guam Naval Computer and Telecommunications Area Master Station (NCTAMS), Bldg 150.
  - No on-site customer data recording to be provided.
  - System mission life greater than 5 years.
  - HIJ compatibility not an **initial** consideration.
  - External element changes not studied in detail.

† - Some options that do not support S- and K- band customers have been included to be consistent with the guiding HQ memos (i.e. replication of GRTS, relocation of GRTS)

Study Approach

- Approach
  - Focus on providing ***TDRS*** and ***customer*** support.
  - Describe systems, identify cost, schedule and support capability.
  - Think “out of the box”.... do not immediately discount unconventional approaches:
    - Consider advances in electronics, redundancy, control, TDRS TT&C concepts, data transport and station operations.
  - Attempt to identify any other areas that could reduce station cost:
    - “Store and forward” data to customers.
    - Data transport technologies.
    - Elimination of tracking data requirements.
    - Others...

Study Approach

What type of system could be implemented?

- Build an "off the shelf" MCOTS/COTS system
- Build a new system using (near term) state of the art technology
- Replicate the GRTS system
- Use SGLT6
- Others

How could the system be procured?

- Procure and install the system totally through industry
- Procure and install using standard Government methods
- Other

How would the system be controlled?

- Autonomous control
- Control via local operators
- Control via WSGTU

How would the system be scheduled?

- NCC directly to Guam
- NCC through WSGTU to Guam
- Customer directly to Guam
- Customer through WSGTU to Guam

How would the data get onto and off of the site?

- Real-time directly to and from the customers
- Real-time through the WSGTU
- "Store and forward"
- TTC and tracking data

What is the system capable of?

- Full compatibility with SN customers
- Partial compatibility with SN customers

Guiding NASA Headquarters Memos

National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

Reply to Attn of: OX

FEB 26 1996

TO: Goddard Space Flight Center
Attn: 100/Director

FROM: O/Associate Administrator for Space Communications

SUBJECT: Permanent Closure of the Space Network (SN) Zone of Exclusion (ZOE)

During the latter part of last year the Office of Space Communications (OSC) requested an evaluation be performed to determine the minimal systems capability and location for SN services to provide the current and projected NASA customer community with SN support in the area referred to as the ZOE. The OSC goals for this system capability are to maintain cost efficiency, mission safety, and increased reliability similar to that of the primary SN coverage area. This evaluation, with a Critical Design Review (CDR) scheduled, has concluded that a SN Guam Remote Ground Terminal (GRGT) would best support the SN mission in the ZOE. It was further concluded that adequate U.S. Government facilities and commercial services exist at the Guam Naval Communications Transmitter Area Master Station (NCTAMS) to support such a terminal and that these facilities and services have the capability of supporting a more robust expansion of SN capabilities in the future, should mission requirements dictate.

Therefore, I am delegating to the Director, Space Network the responsibility for authorizing the commencement of the implementation of a minimal system capability at Guam upon determination at the CDR that the OSC goals will be met. I am further delegating to the Director, Goddard Space Flight Center the responsibility for implementation of this system at Guam upon authorization. The implementation is to accomodate [sic] a readiness capability to the support of the first International Space Station (ISS) launch presently planned for early December 1997.

As a result of the constrained implementation period and criticality of the support to the ISS mission, I am by separate correspondence, requesting the assistance of the Chief of Naval Operations in establishing the SN GRGT presence at the Guam NCTAMS facility.

ORIGINAL SIGNED BY
Charles T. Force

REPLICA

National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

Reply to Attn of: OX

NOV 20 1995

TO: Goddard Space Flight Center
Attn: 500/Director, Mission Operations and Data Systems

FROM: OX/Director, Space Network

SUBJECT: Planning for Guam Remote Ground Terminal (GRGT)

At the Code 500 GRGT Implementation review presentation to Headquarters (November 1), authorization was given to proceed with the project only as far as CDR (Phase A). This incremental approach has been taken because the contemplated implementation costs are too high as presently identified. We expect reduced implementation cost opportunities as requirements become better defined over the next several months. In the interim, we want to take steps to insure that costs associated with this Phase A work leading up to the CDR are known and controllable, and that NASA has a fallback position if substantial cost savings fail to materialize.

Please provide the cost and schedule associated with Phase A activities as soon as possible. This is essential to support the proper accountability relationships.

To provide for the possibility that insufficient cost reductions are found, thus preventing the funding of a full-capability Ground Terminal, include in Phase A planning a fallback position based on replication of the Canberra Remote Ground Terminal on Guam. The decision made at the review to pursue the Navy (NCTAMS) site should be maintained even if this fallback becomes prudent (to accommodate future expansion of the Guam Ground Terminal.) Please complete planning for this fallback option as soon as possible so we will know the cost for a minimal Guam capability.

As noted at the review, the estimated recurring costs for the Guam Ground Terminal, consisting primarily of costs for data transfer back to the US, are also higher than acceptable. We will pursue this issue; there are lower cost options. Please have your NASCOM folks contact Code OX to discuss these options.

ORIGINAL SIGNED BY
Wilson T. Lundy

REPLICA

Key Extracts from NASA Memos

- Force Letter (2/26/96):

  "The OSC goals for this system [Guam] capability are to maintain <u>*cost efficiency*</u>, <u>*mission safety*</u>, and <u>*increased reliability similar to that of the primary SN coverage area*</u> ... and that these facilities and services have the <u>*capability of supporting a more robust expansion of SN capabilities in the future*</u>, should mission requirements dictate."

  - This extract mentions several attributes for which metrics have been developed to help assess the different systems. The metrics may assist in determining how well each architecture meets the OSC goals.

Key Extracts from NASA Memos

- Lundy Letter (11/20/95):

  "We expect *reduced implementation cost opportunities as requirements become better defined over the next several months* ... NASA has a *fallback position if substantial cost savings fail to materialize* ... a *fallback position based on replication of the Canberra Remote Ground Terminal on Guam* ... Please complete planning for this fallback option as soon as possible so we will know the cost for a minimal Guam capability."

  - This extract refers to the current approach of the "cable stretched SGLT6". Although the costs have fallen as the SGLT6 design has matured, different options (which can be considered as "fallback" options) are presented in this study. The specific statement asking for replication of Canberra at Guam is covered in detail.

Revisit of Concepts for a TDRSS Capability at Guam (8/16/95)

Concepts for a TDRSS Capability at Guam

- The the original concepts formulated last August for a TDRS ground station at Guam were re-visited to determine applicability to this study.
- Costs and schedule were re-evaluated, technical approach was not re-evaluated.

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Concepts for a TDRSS Capability at Guam[1] (8/16/95)

	INITIAL COST	SCHEDULE	PROS/CONS
Option 1 (SGLT-6)	**$23.87M** **$20.0[2]**	**18 mos.** **23[3]**	1. Quickest implementation 2. Sustatined from STGT 3. Save costs at WSGTU 4. Lose 1 SGLT from WSC
Option 2 (New SGLT)	**$50-70M** **$77.2[4]**	**>24 mos.** **48+[5]**	1. Highest Cost 2. Longest Schedule 3. Retains SGLT-6 @ WSC 4. Sustained from STGT
Option 3 (GRTS-Like Approach)	**$34.4M** **$34.4[6]**	**21 mos.** **24+[7]**	1. Option for 16 mo. using GN RER for TT&C and TURFTS and WSGT equipment for USS 2. Lends itself to evolving capability.

Updates are shown in white text on black background - all other data from original 8/16/95 chart

Footnotes:

(1) - Original F. Stocklin Concept studies performed from July 95 - August 95

(2) - SGLT-6 target cost. Also note that there was an math error of $465K (low) in the August study

(3) - Assumes funding and contract vehicles are in place at beginning of project - critical path seems to be long lead (Ant/Inv Mux) procurements

(4) - SGLT-7 estimated cost. Includes $7M contingency.

(5) - Almost one year would be needed to award contract; more than one year would be needed to fabricate, deliver, install and test hardware and software

(6) - No change

(7) - Software development for the SPAR (formerly GARP) receiver increases the schedule estimate

Study Architectures

Study Architectures

- Resultant major system concept architectures (studied to varying degrees of detail):
  - Replicate the GRTS system (“Replicate GRTS”).
  - Physically move the GRTS to Guam (“Relocate GRTS”).
  - Implement a COTS/MCOTS system using lessons learned from GRTS (“New GRTS”).
  - Implement a totally new system from scratch (“State of the Art”).
  - Procure a new, complete SGLT (“SGLT-7”).
  - Continue with the current approach (“SGLT-6”).

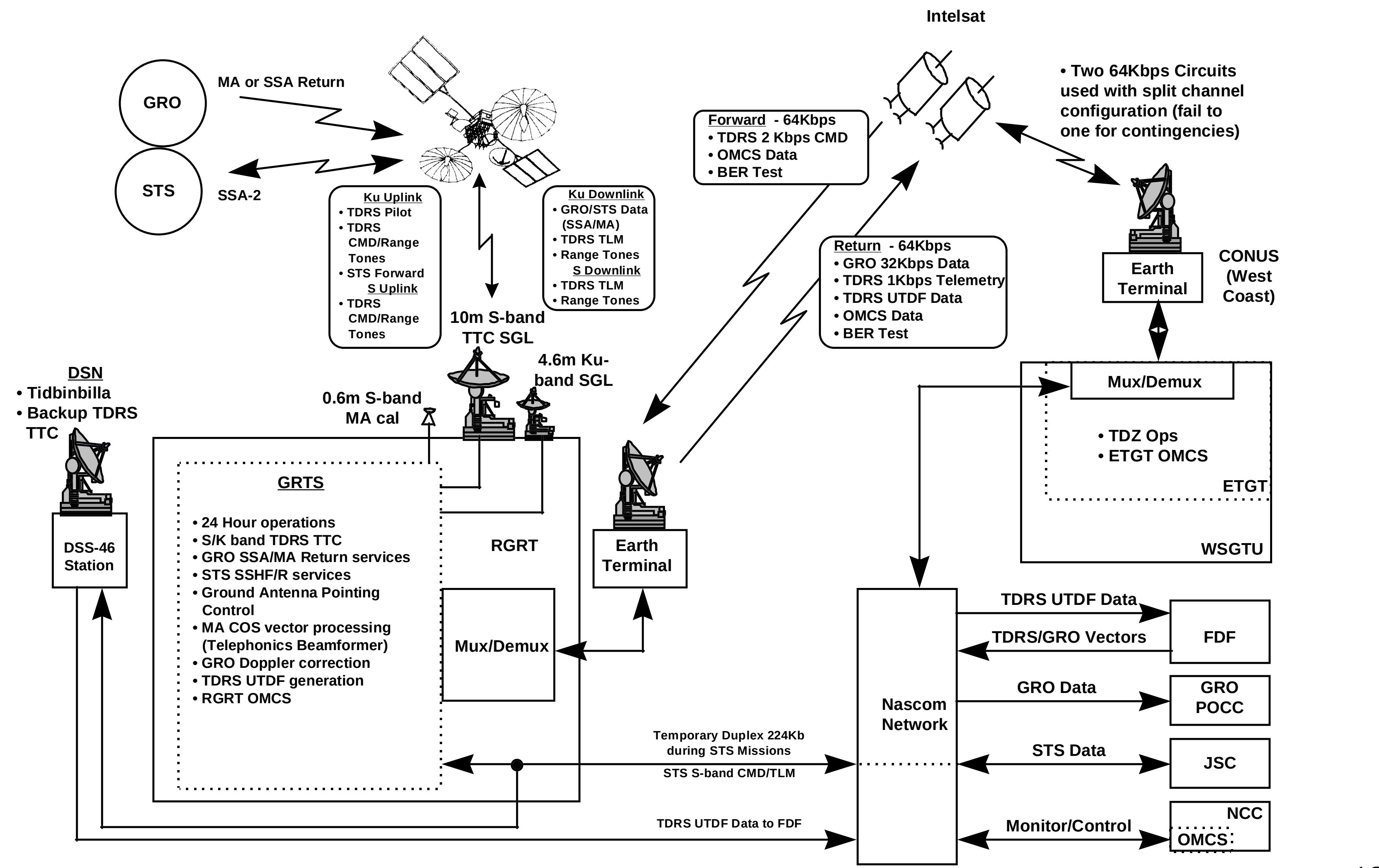
Study Architectures

- Other system concepts (not studied in detail):
  - Use piece parts from SGLT6 to build a system
    - Discounted due to lack of significant differentiation from current (SGLT6) approach.
  - Use old WSGT/NGT and/or other excessed equipment
    - Discounted due to high life cycle cost.
  - De-install and use SGLT5 (saves adding MA capability to SGLT6)
    - Discounted due to need for SGLT5 at WSC and significant potential impacts to HIJ baseline effort.

GRTS Baseline
(Current Canberra Installation)

[Reviewed to apply lessons learned from GRTS to this study]

GRTS Configuration



GRTS Baseline Capabilities

- GRTS system is manually scheduled
  - GRO submits electronic SARs to NCC. The NCC then translates SAR into a human readable schedule and creates a text file on the OMCS WAN. ETGT and GRTS then access the file to manually enter the schedule information into respective systems.
  - Raw scheduling data is provided weekly (covering a 1-week period) to allow GRTS to examine the schedule for time to plan system maintenance and perform MA calibrations.
  - Detailed scheduling data is provided daily (covering a sliding 72-hour period) for planning GRO and STS customer support.

GRTS Baseline Capabilities

- Acquisition Data (state vectors) is manually handled
  - TDRS and user state vectors are manually entered at both NCC and ETGT. The user vector data is electronically transmitted from the NCC to GRTS (via the OMCS) where it is automatically downloaded to the equipment. The TDRS vector is manually entered at the ETGT for TDRS command and control.
- Staffing
  - GRTS “equivalent” staffing is 3 FTE’s - actual personnel are shared with DSN site.
  - Overhead functions <u>are not</u> included in the 3 FTE number (security/admin/etc.).
  - Staff literally travels back and forth between the GRTS functions and DSN functions.

GRTS Baseline Capabilities

- Assumption of additional customer support would require staffing increase and would very likely lead to more human error - presently, GRTS supports only GRO and STS
  – GRO schedules approximately 9 events per day, each event lasts about 30 minutes.
  – GRTS is usually in a “default” setup for GRO support (i.e. the receivers are pre-configured for GRO and simply wait for a signal).
  – STS support consists of an average of 6 events per mission, each event normally lasts less than 10 minutes.
- Even at the present customer support level, the scheduling/acquisition process is somewhat stressed.

GRTS Baseline Capabilities

- GRTS System Capabilities:
  - One SSA return only and/or one MA return only service
    - Two TDRSS User RF Test System (TURFTS) receivers and one Telephonics beamformer provide support.
    - Simultaneous SSA capability would require USP/TURFTS software modifications.
    - TURFTS receivers tested to 2Mb (4Ms).
  - Shuttle S-band return (96Kb/192Kb) provided by a resurrected WSGT SSRE receiver
    - Microdyne receiver functions as a backup to the SSRE and can support some GN modes (I.e. IUS).
  - Shuttle S-band forward at fixed frequencies
    - No capability for non-shuttle customer forward services .
  - No customer tracking capability

GRTS Baseline Capabilities

- Outbound Line rate is 56Kb
  - Two 56 Kb full duplex lines are used for communication
    - Lines carry GRO 32Kb data, TDRS TLM (1K), TDRS CMD (2K), TDRS UTDF data, RGRT control and status (OMCS).
    - Normal operations configure for data to be split over the two communications lines; if one line fails, all operations can be configured on the remaining line.
  - Voice coordination performed on a separate circuit.
  - During Shuttle operations, a full duplex 224Kb line is used (removed from DSN service).

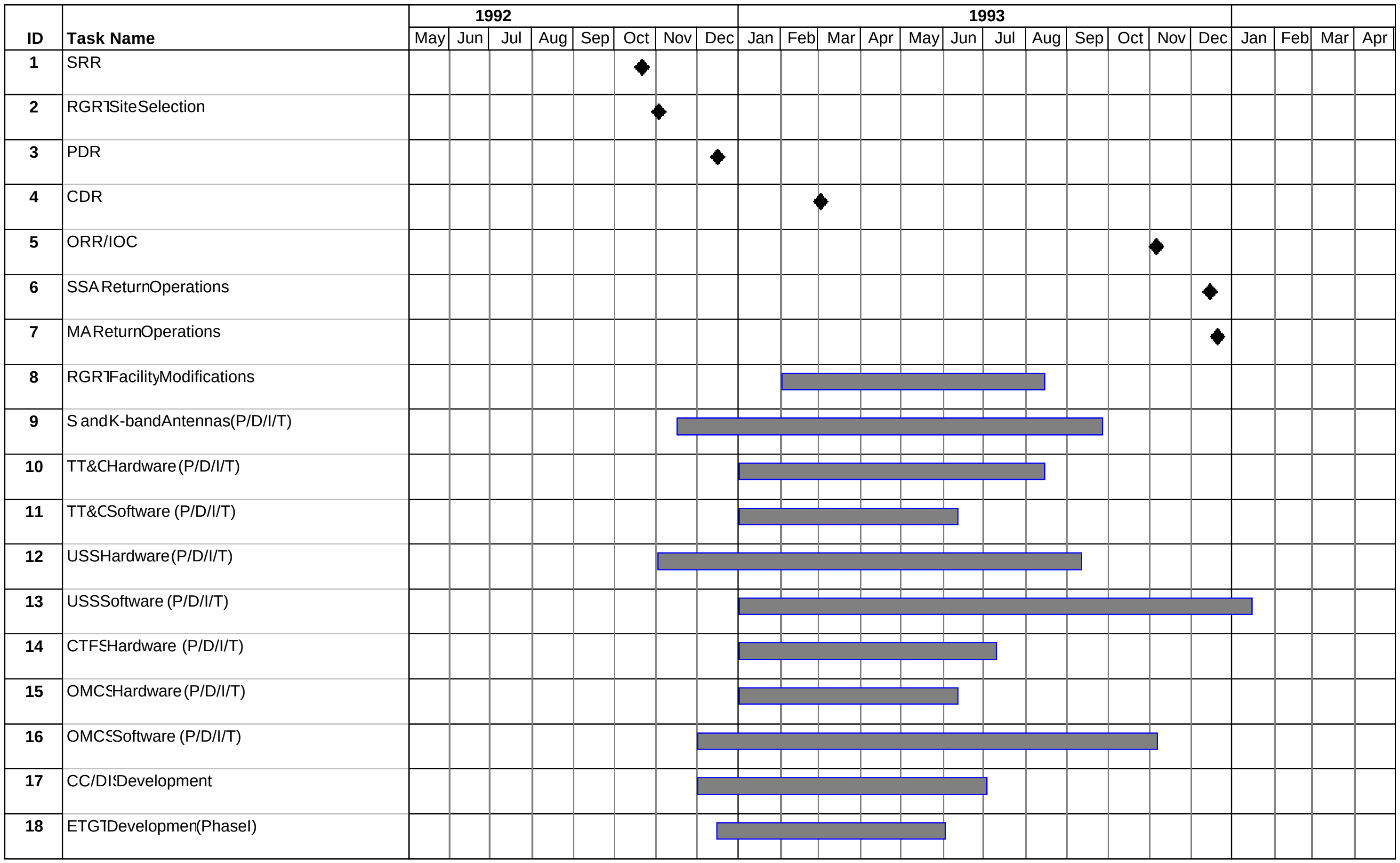
GRTS Cost

- GRTS Cost
  - Total of $12.3M spent on hardware and ATSC labor ($3.5M labor, $1M of which was NRE).
  - $1.7M expended on GTE and site ATSC labor from M&O
    - Does not include NASCOM timeplex equipment ($123K).
  - $150K GSFC ATSC test support.
  - No CS manpower costs included.

GRTS Cost = $14.3M (FY92 dollars)

GRTS Schedule

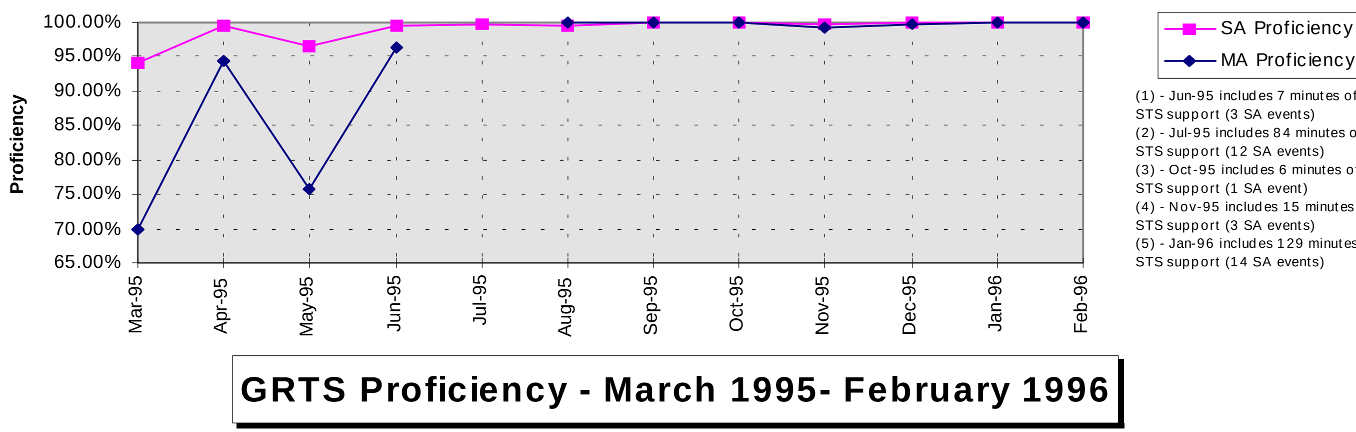
GRTS Implementation Schedule



(data from F. Stocklin 1/5/94 MSR)

GRTS Operations Proficiency

	Mar-95	Apr-95	May-95	Jun-95	Jul-95	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95	Jan-96	Feb-96
MA Minutes	4252	1430	185	53		192	116	64	297	1176	24	132
SA Minutes	4391	6887	7017	8647	9298	9028	7960	8810	8192	7308	9111	8065
Total Minutes	8643	8317	7202	8700	9298	9220	8076	8874	8489	8484	9135	8197
MA Events	137	45	8	2		6	3	2	9	36	1	4
SA Events	149	229	243	277	303	283	259	294	262	232	295	267
Total Events	286	274	251	279	303	289	262	296	271	268	296	271
MA Minutes Lost	1278	79	45	2		0	0	0	2	3	0	0
SA Minutes Lost	263	27	246	46	32	37	9	0	27	3	5	0
Total Minutes Lost	1541	106	291	48	32	37	9	0	29	6	5	0
MA Proficiency	69.94%	94.48%	75.68%	96.23%		100.00%	100.00%	100.00%	99.33%	99.74%	100.00%	100.00%
SA Proficiency	94.01%	99.61%	96.49%	99.47%	99.66%	99.59%	99.89%	100.00%	99.67%	99.96%	99.95%	100.00%
Total Proficiency	82.17%	98.73%	95.96%	99.45%	99.66%	99.60%	99.89%	100.00%	99.66%	99.93%	99.95%	100.00%

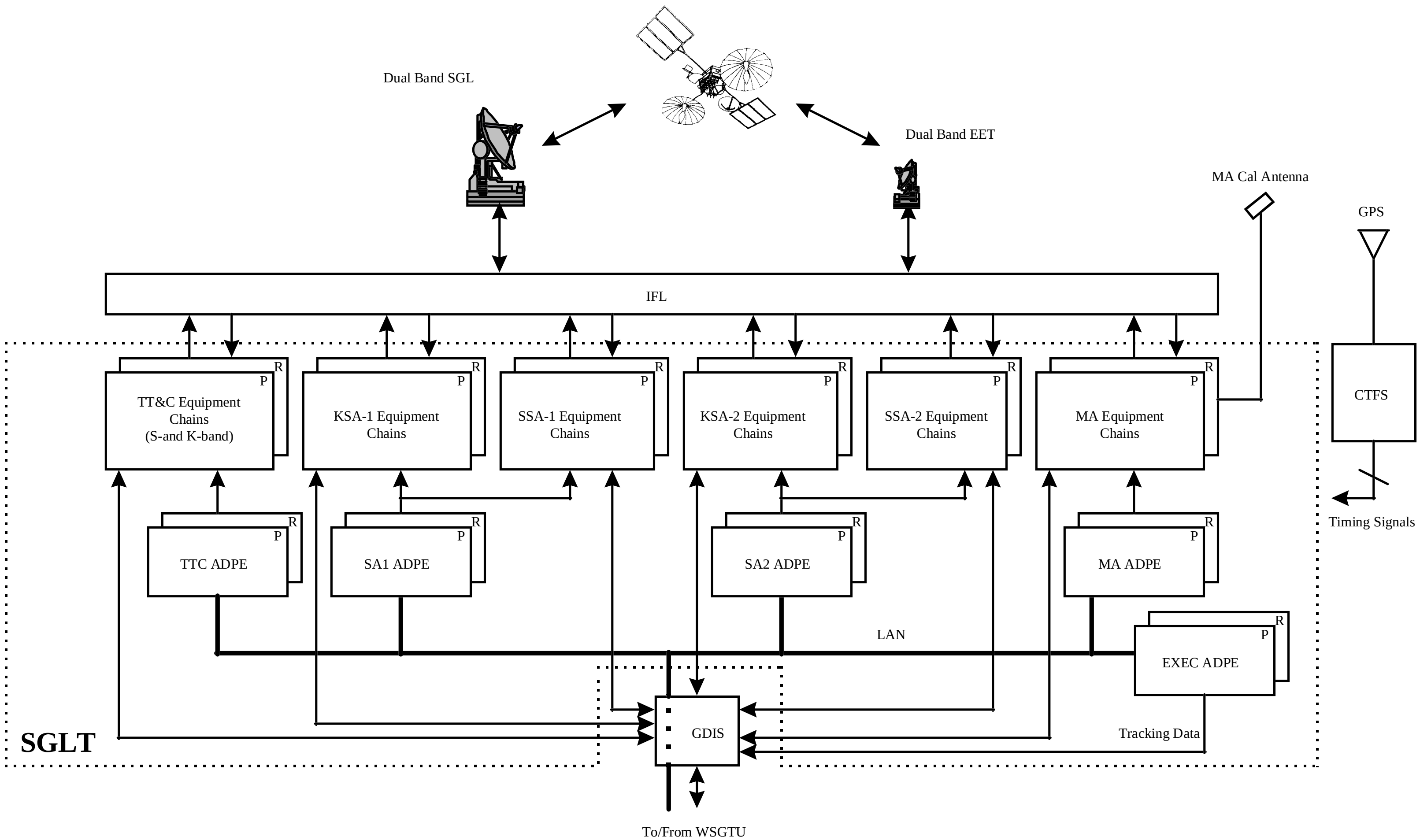


GRTS Proficiency - March 1995- February 1996

(1) - Jun-95 includes 7 minutes of STS support (3 SA events)
(2) - Jul-95 includes 84 minutes of STS support (12 SA events)
(3) - Oct-95 includes 6 minutes of STS support (1 SA event)
(4) - Nov-95 includes 15 minutes of STS support (3 SA events)
(5) - Jan-96 includes 129 minutes of STS support (14 SA events)

SGLT-6 at Guam
(Current approach)

SGLT6 at Guam System Diagram



SGLT6

- System Concept/Capabilities
  - Install SGLT6 at Guam. Provides automated operation, dual SA (SSA and KSA) forward and return, one MA forward and two MA return services, all supportable simultaneously. All Shuttle forward and return services (except for K-band return analog signals), end-to-end test, customer tracking. Uses "cable stretch" approach for connection to WSC (WSGTU).
- Benefits
  - Full support of current SN community.
  - Controlled in same manner as all other SGLTs; "cable stretch" approach minimizes changes to customer and external element interfaces.
- Drawbacks
  - No return data delay capability.

SGLT6

- SGLT6 Considerations
  - Significant hardware investment already made by NASA.
  - Proven design capabilities.
  - Proven high performance, highly reliable system.
  - Hardware design consistent with (future) HIJ modifications.
  - Integrated, automatic scheduling and monitoring capability.
  - Simplified logistics, training.
- Risks
  - GDIS inverse multiplexer development and procurement.
  - Potential LAN timing issues.
  - Antenna Control Unit interface.
  - Facility modification schedule.

Relocate GRTS

Relocate GRTS

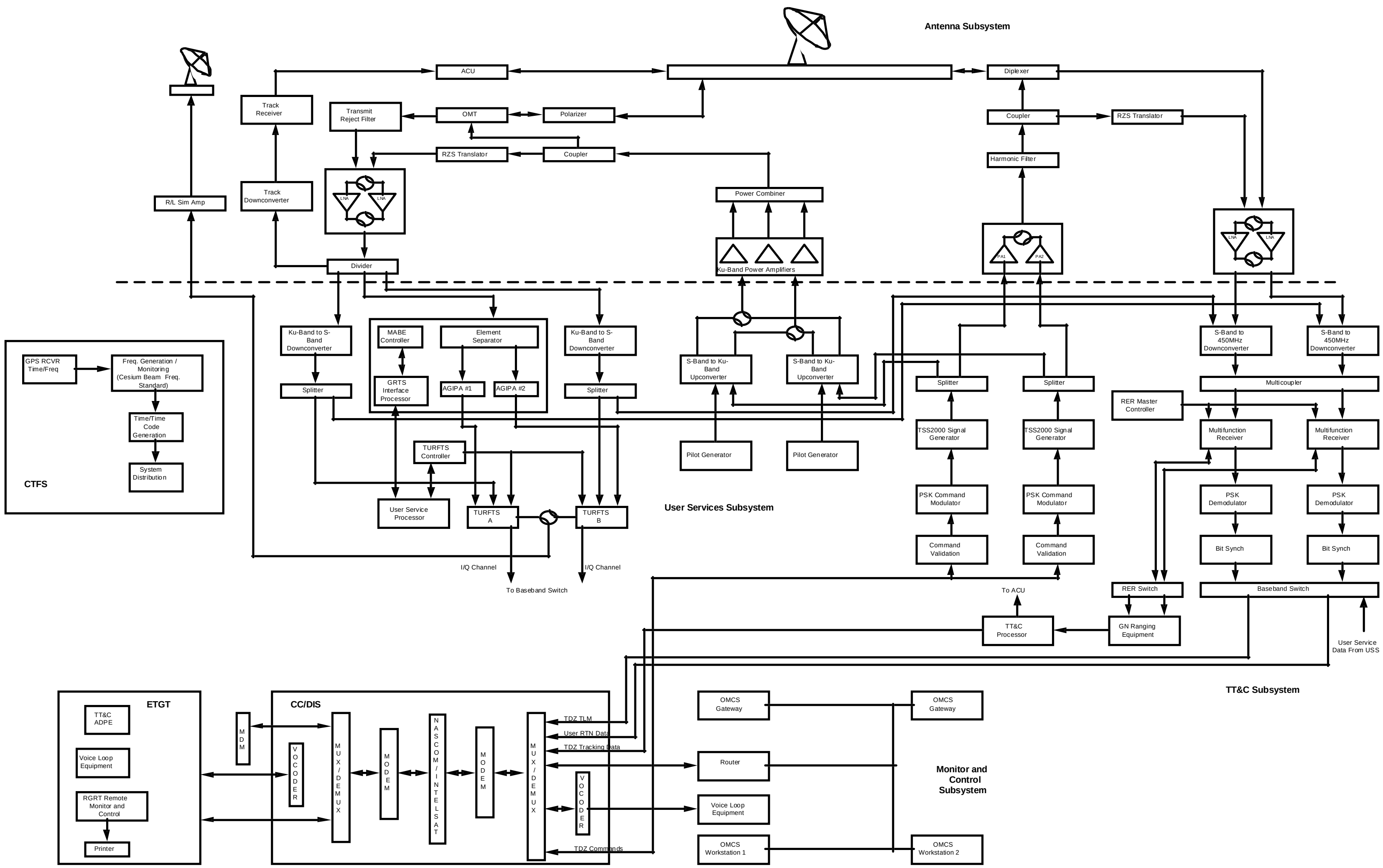
- System Concept/Capabilities
  - Move the existing Canberra GRTS system to Guam and install. Current GRTS capabilities to be retained. Provides highly manual operation, two receivers for SSA/MA return, no forward link (except for Shuttle SSA), no KSA, no end-to-end test, no customer tracking.
- Benefits
  - Lowest cost and fastest option to establish minimal system capability at Guam.
- Drawbacks
  - Cannot support current SN community.
  - Highly manual operation.
  - Relatively high staffing requirements for 24x7 operation (compared to service capability).

Relocate GRTS

- Risks
  - Downtime during transition may not be acceptable (from a GRO science/mission perspective)
    - Attempts to keep Canberra operational in a reduced mode (i.e. move MA to Guam, keep SA and/or TTC up at Canberra) will force a redesign of the OMCS.
  - Attempting to use station for multi-mission capability will stress operators.
  - Facility modification schedule.

Replicate GRTS

Replicate GRTS System Diagram

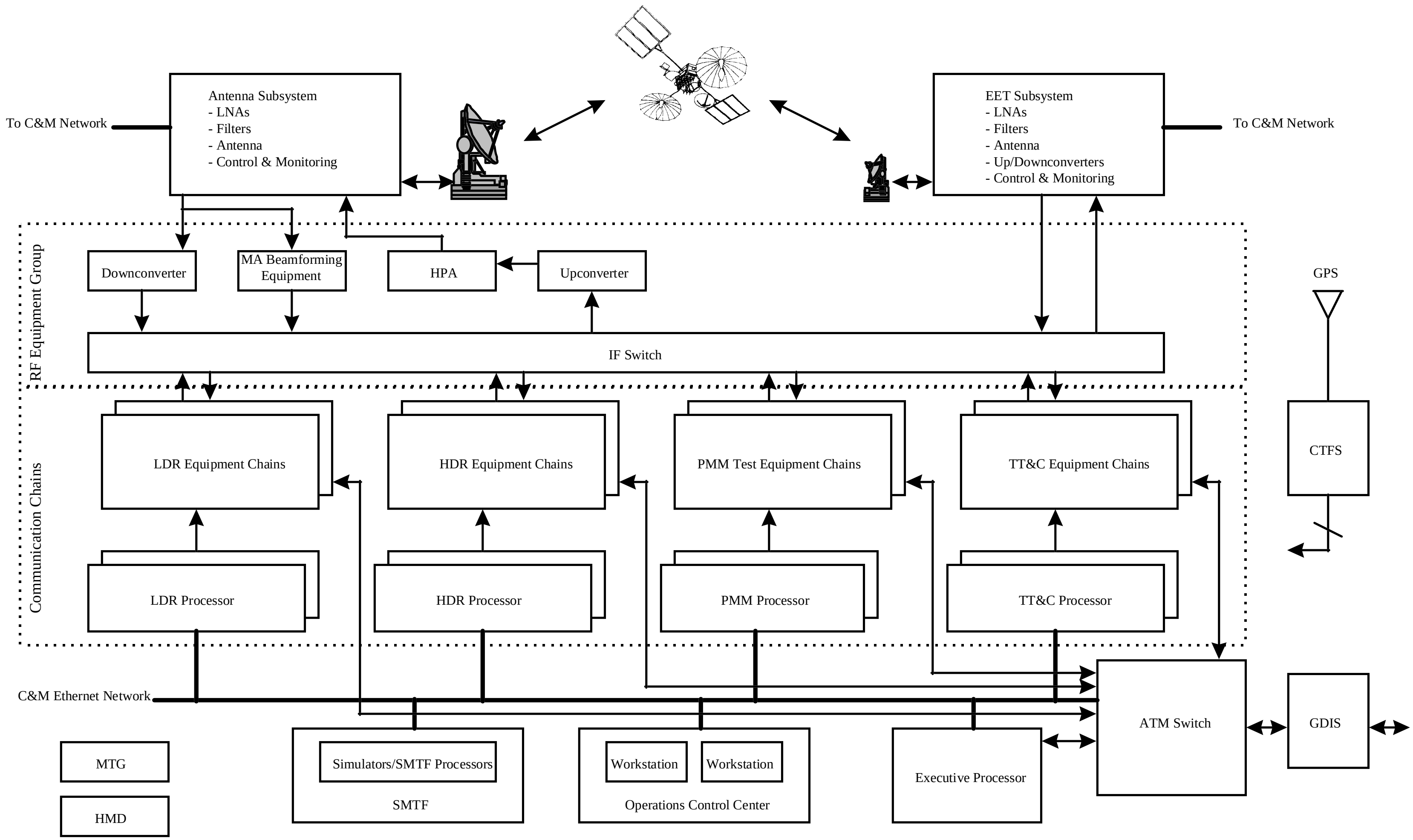


Replicate GRTS

- System Concept/Capabilities
  - Replicate GRTS at Guam. Purchase new TURFTS, OMCS, USP, etc. Provides same capabilities as baseline GRTS.
- Benefits
  - Can ***potentially*** keep GRTS operational during implementation.
- Drawbacks
  - Cannot support current SN community.
  - Highly manual operation.
  - Relatively high staffing requirements for 24x7 operation (compared to service capability).
- Risks
  - MABE relocation (breakage).
  - Long lead procurement items (antenna).
  - Facility modification schedule.

New "State of the Art" System

New “State of the Art” System Diagram (Baseline)



New “State of the Art” System

- System Concept/Capabilities
  - Implement an entirely new ground station using current, “state of the art” hardware and software. Provides automated operation, dual SA (SSA and KSA) forward and return, MA forward and dual link MA return services, all supportable simultaneously. All Shuttle forward and return services, end-to-end test, customer tracking.
- Benefits
  - Takes advantage of recent advances in software and hardware technology.
  - Easily modified for direct data distribution - uses commercial standards for data transport.
  - Capability for more autonomous station/TDRS control.

New “State of the Art” System

- Drawbacks
  - High cost.
  - Long procurement and implementation time.
- Risks
  - Development schedule (especially high and low rate receiver development).

SGLT7

SGLT7

- System Concept/Capabilities
  - Implement an entirely new ground station by procuring another SGLT. Provides capabilities equivalent to SGLT6 (with MA).
- Benefits
  - Retains capability for 6 SGLT WSC operation.
  - Reuse significant portions of the design developed for WSC .
- Drawbacks
  - High overall cost.
  - Long procurement and implementation time.
- Risks
  - Outdated/inaccurate drawings.
  - Control from WSC would require extensive rework at WSC.

New GRTS (COTS/MCOTS)

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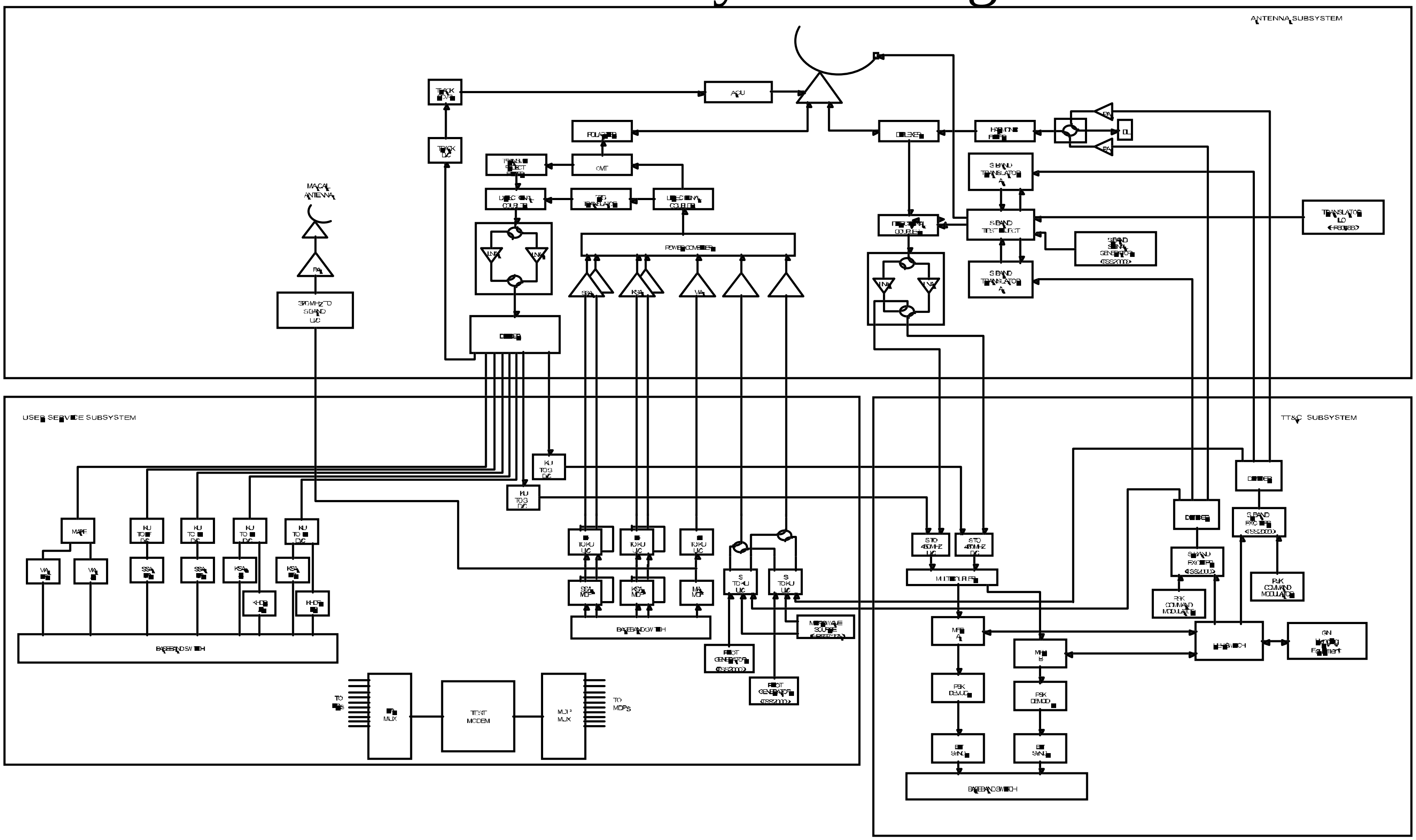
New GRTS (COTS/MCOTS) Configuration

New GRTS System Diagram



New GRTS (COTS/MCOTS)

- System Concept/Capabilities
  - Implement the ground station by procuring COTS and MCOTS software and hardware systems. Provides redundancy and full (SSA/KSA/MA) forward, return and tracking customer support capabilities.
- Benefits
  - Relatively low cost.
  - Full customer service capabilities .
- Drawbacks
  - External impact modification costs.
- Risks
  - Receiver development.
  - Facility modification schedule.

Common Issues

Station Customer Configuration/Reconfiguration Control

- Station Customer Configuration/Reconfiguration Control
  - Customer configuration/reconfiguration/service monitoring and control functions similar to the NCC (75K LOC control and status system) are needed if the ground station is to accept reconfigurations directly from customers. Cost: $7.5M plus ADPE.
  - New architectures in this study (New GRTS, SGLT7, "State of the Art") did not include customer control/monitor systems as part of the system itself. The assumption is that an external entity would control the station.
  - Revised architectures include existing external (WSC) control (Replicate GRTS, Relocate GRTS, SGLT6) .

TDRS Functions

- TDRS Control/Monitoring
  - All estimates assume external TDRS control. Internal control would require additional staffing in some architectures, and additional ADPE/software systems and staffing in others.
  - Some systems have a built in capability of on-site satellite control (SGLT7, “State of the Art”, SGLT6) while the others do not due to lack of ADPE and TDRS control software.

TTC Function Capabilities for Study Architectures

Local Function Capability	Replicate GRTS	New GRTS	New "State of the Art"	Move GRTS	SGLT7	SGLT6
TDRS commanding	✔	✔	✔	✔	✔	✔
TDRS telemetry processing	✔	✔	✔	✔	✔	✔
Control ground antennas	✔	✔	✔	✔	✔	✔
Control TDRS antennas	✗	✗	✔	✗	✔	✔
Determine TDRS attitude	✗	✗	✔	✗	✔	✔
Manage TDRS momentum	✗	✗	✔	✗	✔	✔
Calculate customer and TDRS ephemeris from state vectors	✔	✔	✔	✔	✔	✔
Calculate TDRS ephemeris from internal orbit determination process	✗	✗	✔	✗	✔	✔
TDRS ranging and tracking	✗	✗	✔	✗	✔	✔
Predict solar/lunar intrusions	✗	✗	✔	✗	✔	✔
Plan, execute and monitor TDRS maneuvers and stationkeep the satellite	✗	✗	✔	✗	✔	✔

System Scheduling Considerations

Station Scheduling

- Additional cost **to all architectures** to implement systems at Guam to accept and process schedule data:

Keep Customer Interface as is:

– Modify and use a copy of the existing 150K LOC NCC SPSR (service planning segment) software to make it a standalone system. Cost: $2M ($500K ADPE + $1.5M software modifications).

– Create a new, standalone scheduling system at Guam. Cost: >$10M (>100K LOC) plus ADPE costs.

Change Customer Interface (implement a client/server or distributed database architecture):

– New scheduling database system at Guam. Cost: $5-10M (50K-100K LOC) plus ADPE costs.

– Change customer systems. Cost: Unknown.

System Scheduling Considerations

Station Scheduling (cont'd)

- Multiple (NCC+Guam) scheduling systems potentially decrease the efficiency of TDRSS utilization and can complicate customer scheduling
  - Customer service scheduling flexibility becomes more manually intensive operation for the NCC and/or the customer (e.g. shifting schedules between TDZ/TDW).
- Maintenance of dual systems for service accounting and service assurance functions (NCC and Guam).

Data Transport Option

- Customer “Store and Forward” Data Transport
  - Expect need for minimal real-time return link data or customers probably won’t use Guam ... they would simply keep using TDE/TDW.
  - Media would have to be shipped or data would have to be transmitted electronically (presumably at a reduced rate) to customers.
  - Less than 24 hour latency for data may be acceptable to most customers (has not been confirmed).
  - Additional equipment and software would be needed at Guam (recorders/control/data buffering/tapes/degaussers, etc.).
  - Changes to customer systems may be needed to accept tapes or configure for playback.

Future Data Transport Considerations

- External Data Communications Protocols
  - Transition to commercial protocols (TCP/ATM) for data transport already occurring within the SN.
  - Some architectures support TCP/ATM (i.e. “State of the Art”), others would require more modification.
  - Adaptability to commercial protocols potentially simplifies adding the capability of direct data communications with customers.

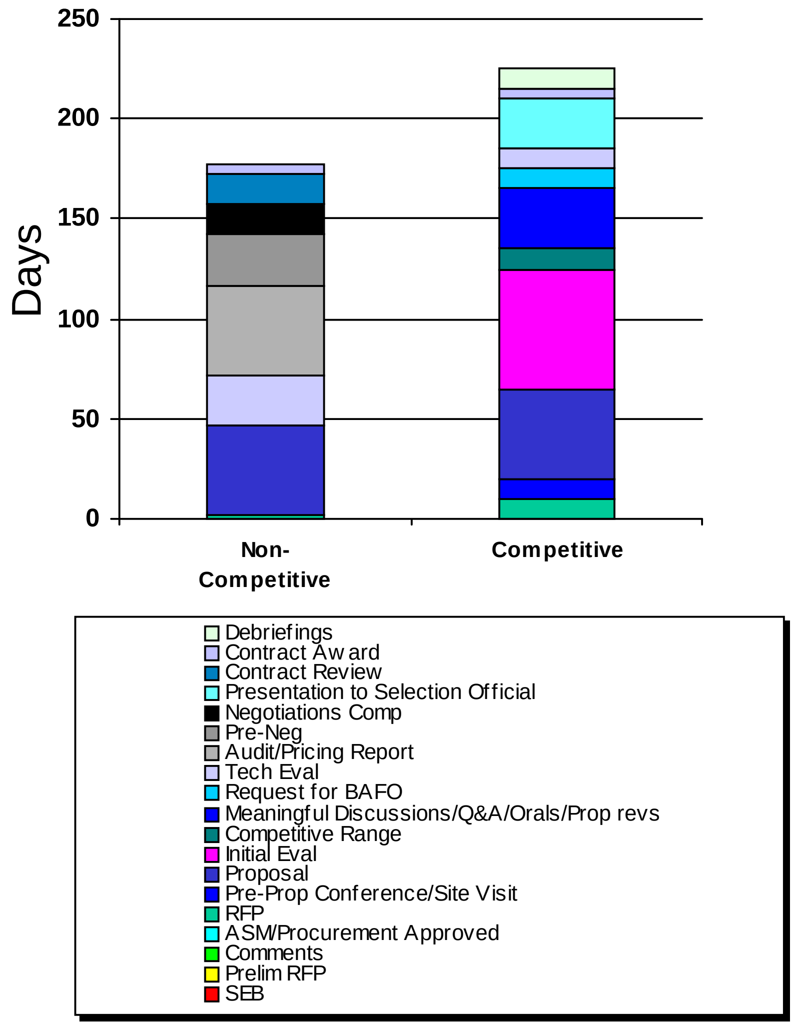
Other Cost Reduction Concepts

- Rescind the requirement for customer tracking from Guam - have customers use TDE/TDW for tracking data
  - Savings depend on architecture - for example, tracking data processing is an integral part of the IR, and is built into many other commercial receivers.
  - Savings by eliminating communications line costs for 56Kb tracking data rate marginal.

New Systems Procurement Considerations

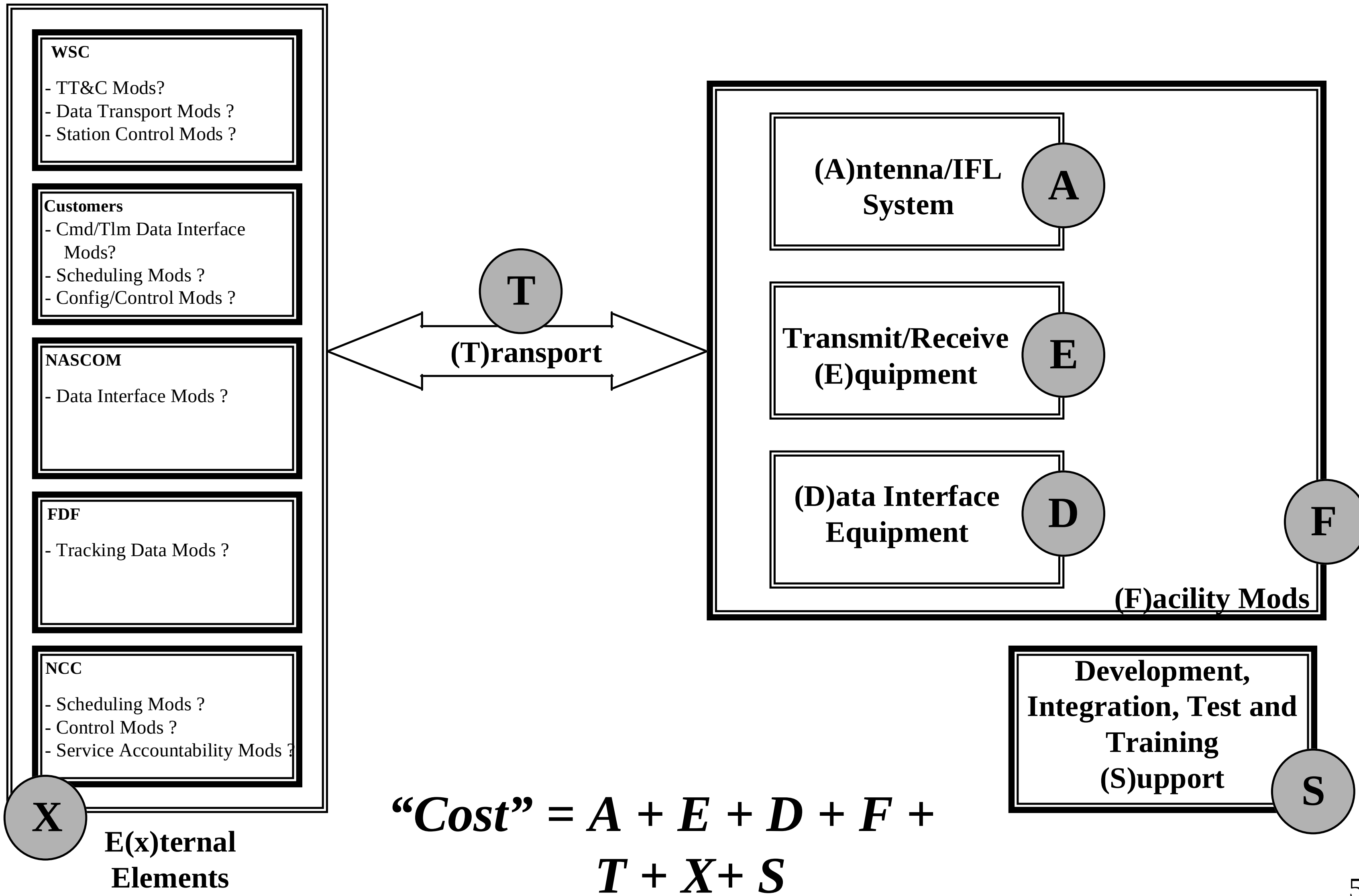
New Systems Procurement Considerations

- Pre-Procurement Activities
  - **Master Buy, Statement of Work, Specifications, Purchase Request, Inhouse estimate prep, itemization of deliverables, Government Furnished Equipment, FIRMR/APR, D&F, S&H, Justification for other than fair and open competition (JOFOC).**
  - **Pre-procurement times vary, but the Guam effort could easily take 6 months.**
- Procurement Activities
  - **Competitive process takes 205 days.**
  - **Non-competitive process is 152 days.**



Cost Concepts

Study Cost Concepts



$$\text{“}\mathit{Cost}\text{”} = A + E + D + F + T + X + S$$

Cost Concepts

- Costs
  - **A**: Antenna and IFL System: 11-m S/Ku antenna system.
  - **E**: Transmit and Receive System: Hardware, firmware, software and control functions for TDRS and customer signal processing.
  - **D**: Data Interface Equipment: Hardware, firmware, software and control functions for interface to the common carrier interface.
  - **F**: Facility Modifications: NCTAMS building/facility changes - Antenna foundations, power/UPS, cooling, flooring, partition mods, etc.
  - **T**: Data Transport: Initial and recurring costs for data transport to and from Guam.
  - **X**: External Elements: Changes required for adapting systems to operate with Guam.
  - **S**: Development, Integration, Test and Training Support: Labor for designing, installing, integrating and testing the system.

Conclusions

System	Requirement Satisfaction E	Requirement Satisfaction S	Requirement Satisfaction R	Cost & Schedule $ M	Cost & Schedule Months	Ops Concepts	Life Cycle Aspects	Major Risk Areas	Notes
Replicate GRTS *Capabilities:* ~~KSAF~~ ~~KSAR~~ ~~SSAF~~ **SSAR(1)** ~~MAF~~ **MAR(2)** **SSHF(1)** **SSHR(1)** ~~KSHF~~ ~~KSHR~~ ~~Track~~ ~~EET~~	**39**	**86**	**95**	**$ 15.0** *10* *50* *100*	**17 mos.** *6* *30* *60*	- Remote SATCON (TTC) required - On-site engineering and tech support - *Cannot* support current/future SN community - 14 personnel required for 7x24 operations (no personnel sharing capability at NCTAMS) - Operational availability relatively low (compared to SGLT6 implementation) due to single string design - Manual scheduling of customer services and manual vector entry - On-site repair (level 1) - No/minimal changes to external elements (re-use ETGT)	- Logistics costs potentially increase due to unique/obsolete parts (e.g. SSRE) - Difficult expansion for HIJ or to enhance services	- MABE Relocation (breakage risk) - Long lead items (Antenna procurement) - Facility modification schedule - New comm line needed for shuttle data (>56Kbps)	- Low technical risk - lessons learned from GRTS can be applied - Potential for $3.3M savings if GFE is available - Shuttle forward link transmitted at fixed frequencies - Should consider Timplex upgrade, OMCS automation (vectors, multi-customer data), more receivers for backup, automate Shuttle equipment setup, add OMCS test bed
New GRTS (COTS ground station) *Capabilities:* **KSAF(2)** **KSAR(2)** **SSAF(2)** **SSAR(2)** **MAF(1)** **MAR(2)** **SSHF(2)** **SSHR(2)** **KSHF(2)** **KSHR(2)** **Track** **EET**	**88**	**97**	**99**	**$ 23.9** *10* *50* *100*	**23 mos.** *6* *30* *60*	- Remote SATCON (TTC) required - On-site engineering and tech support - 17 personnel required for 7x24 operations - Operational availability comparable to SGLT6 implementation - limited redundancy - Capable of modification for fully automated scheduling of customer services and vector entry and equipment control - On-site repair (level 1) - Changes to external elements for scheduling/control/data interface (not included in cost)	- New, unique ground station, logistic costs likely to be fairly high - Difficult expansion for HIJ or to enhance services	- System control development, High Data Rate receiver development - Long lead items (IR/MDP procurement, Antenna procurement) - Staffing estimate may not accommodate full operations/maintenance needs - External element modification schedule/costs - MABE relocation (breakage) - Facility modification schedule	- Potential for $2.7M savings if GFE is available - One redundant downconverter, one redundant IR for all low rate services, one redundant HDR for high rate, and one redundant MDP/upconverter for forward services - Implementation uses newly available 200W HPAs - Advanced RER could replace MFRs and RE when development is finished (Note: development of the ARER has limited funding) - High data rate receivers could be supplied by various mfrs (IEC, Harris, Motorola, Loral WDL, Semco/Loral)

System	Requirement Satisfaction			Cost & Schedule		Ops Concepts	Life Cycle Aspects	Major Risk Areas	Notes
	E	S	R	$ M	Months				
New "State of the Art" Terminal (Baseline w/Redundancy) *Capabilities:* **KSAF(2) KSAR(2)** **SSAF(2) SSAR(2)** **MAF(1) MAR(2)** **SSHF(2) SSHR(2)** **KSHF(2) KSHR(2)** **Track EET**	**74**	**100**	**100**	**$ 66.9** *10* *50* *100*	**54 mos.** *6* *30* *60*	- Remote or local SATCON (TTC) - On-site engineering and tech support - 20 personnel required for 7x24 operations - Operational availability comparable to SGLT6 implementation - limited redundancy - Capable of modifications for fully automated scheduling of customer services - Data transport via ATM - On-site repair (level 1+) with included HMD capability - Changes to external elements for scheduling/control/data interface (not included in cost)	- New, unique ground station, logistic costs high - Moderately difficult expansion for HIJ	- Low Rate receiver development - Software development/COTS integration - External element modification schedule/costs	- Pooled redundancy (by group; HDR, LDR, PMM, TTC) - Longest procurement/implementation and among highest cost options
New "State of the Art" Terminal (Alternate w/Redundancy) *Capabilities:* **KSAF(2) KSAR(2)** **SSAF(2) SSAR(2)** **MAF(1) MAR(2)** **SSHF(2) SSHR(2)** **KSHF(2) KSHR(2)** **Track EET**	**74**	**100**	**100**	**$ 66.7** *10* *50* *100*	**54 mos.** *6* *30* *60*	- Remote or local SATCON (TTC) - On-site engineering and tech support - 20 personnel required for 7x24 operations - Operational availability comparable to SGLT6 implementation - limited redundancy - Capable of fully automated scheduling of customer services - Data transport via ATM - On-site repair (level 1+) with included HMD capability - Changes to external elements for scheduling/control/data interface (not included in cost)	- New, unique ground station, logistic costs high - Moderately difficult expansion for HIJ	- Low Rate receiver development - Software development/COTS integration - External element modification schedule/costs	- Service chain level redundancy (by service; KSA1, KSA2, SSA1, SSA2, MA, TTC) - Longest procurement/implementation and among highest cost options

System	Requirement Satisfaction			Cost & Schedule		Ops Concepts	Life Cycle Aspects	Major Risk Areas	Notes
	E	S	R	$ M	Months				
Relocate GRTS *Capabilities:* ~~KSAF~~ ~~KSAR~~ ~~SSAF~~ **SSAR(1)** ~~MAF~~ **MAR(2)** **SSHF(1)** **SSHR(1)** ~~KSHF~~ ~~KSHR~~ ~~Track~~ ~~EET~~	**39**	**85**	**95**	**$ 3.7** 10 50 100	**4 mos.** 6 30 60	- Remote SATCON (TTC) required - On-site engineering and tech support - 14 personnel required for 7x24 operations (no personnel sharing capability at NCTAMS) - *Cannot* support current/future SN community - Operational availability relatively low (compared to SGLT6 implementation) due to single string design - Manual scheduling of customer services and manual vector entry - On-site repair (level 1) - No/minimal changes to external elements (already have systems in place)	- Logistics costs potentially increase due to unique/obsolete parts (e.g. SSRE) - Difficult expansion for HIJ or to enhance service	- Facility modification schedule high risk - Equipment breakage - Communication line installation (availability of >56Kb lines for Shuttle data)	- Lowest cost, fastest approach to implementing a ground station (with limited capability) - Schedule assumes facility modifications are finished when equipment is ready for shipment
SGLT-7 (Replicate SGLT-6) *Capabilities:* **KSAF(2)** **KSAR(2)** **SSAF(2)** **SSAR(2)** **MAF(1)** **MAR(2)** **SSHF(2)** **SSHR(2)** **KSHF(2)** **KSHR(2)** **Track** **EET**	**89**	**100**	**100**	**$ 77.2** 10 50 100	**48+ mos.** 6 30 60	- Remote or on-site SATCON (TTC) - On-site engineering and tech support - 14 personnel required for 7x24 operations - Operational availability comparable to SGLT6 implementation - full redundancy - Capable of fully automated scheduling of customer services and vector entry and equipment control - On-site repair (level 1) - Changes to external elements (not included in cost)	- Logistics costs increase due to unique/obsolete parts - Expansion for HIJ fairly straightforward/minimal cost	- Parts availability (redesign) - Procurement/production schedules - Out of date prints	- Minimal additional training requirements

System	Requirement Satisfaction			Cost & Schedule		Ops Concepts	Life Cycle Aspects	Major Risk Areas	Notes
	E	S	R	$ M	Months				
SGLT6 *Capabilities:* **KSAF(2) KSAR(2)** **SSAF(2) SSAR(2)** **MAF(1) MAR(2)** **SSHF(2) SSHR(2)** **KSHF(2) KSHR(2)** **Track EET**	**100**	**100**	**100**	**$ 20.0** *10* *50* *100*	**23 mos.** *6* *30* *60*	- Remote or on-site SATCON (TTC) - On-site engineering and tech support - 14 personnel required for 7x24 operations - Capable of fully automated scheduling of customer services and vector entry and equipment control - On-site repair (level 1) - Minimal changes to external elements (with current ops concept)	- Logistics costs accurately predictable - comparable to single SGLT at WSC - Expansion for HIJ fairly straightforward/minimal cost	- Facility modification schedule - Long lead items (MA IR/MDP procurements, Antenna procurement) - GDIS procurement and implementation - Software modifications for WSC - LAN delay accommodation	- Takeout candidates and Phase I costs incorporated into cost estimate - Minimal additional training requirements

Efficiency Definition

Station efficiency is derived using three factors: *(1) staffing requirements assessed against station service capability*, (2) *logistics cost and complexity*, and (3) *reimbursement capability*. The resultant metric is normalized to the expected "SGLT6 at Guam" value.

1. Total station service capability is divided by the staffing requirement to derive a "service per unit staff" metric. This metric is weighted at 60% due to the effect of costs over the station lifetime.

2. Logistics cost and complexity are estimated. Complexity is the relative difficulty to procure parts (i.e. obsolete parts are more expensive to locate, spare and procure). This metric is weighted at 20%.

3. Reimbursement capability is a sum of the potential income that could be derived across all services for the station. Tracking services are considered at the MA return rate. This metric is weighted at 20%. Rates are determined using the "Non-NASA U.S. Government Customer" rates as follows:

Pricing (CY1995 TDRSS Reimbursement Rates):

1. Non-NASA U.S. Government Customers
   - SA (SSA/KSA) Service $130/min
   - MA Forward Service $30/min
   - MA Return Service $9/min

2. Non-U.S. Government Customers
   - SA (SSA/KSA) Service $194/min
   - MA Forward Service $42/min
   - MA Return Service $13/min

Ref: NASA NMI 8410.2B and 8410.3B dated May 6, 1993, FY95 budget estimate 14CFR Part 1215.

Safety Definition

Mission safety is derived by incorporating a measure of (1) *system operational availability*, and (2) *relative ease of operation.* The resultant metric is normalized to the expected "SGLT6 at Guam" value.

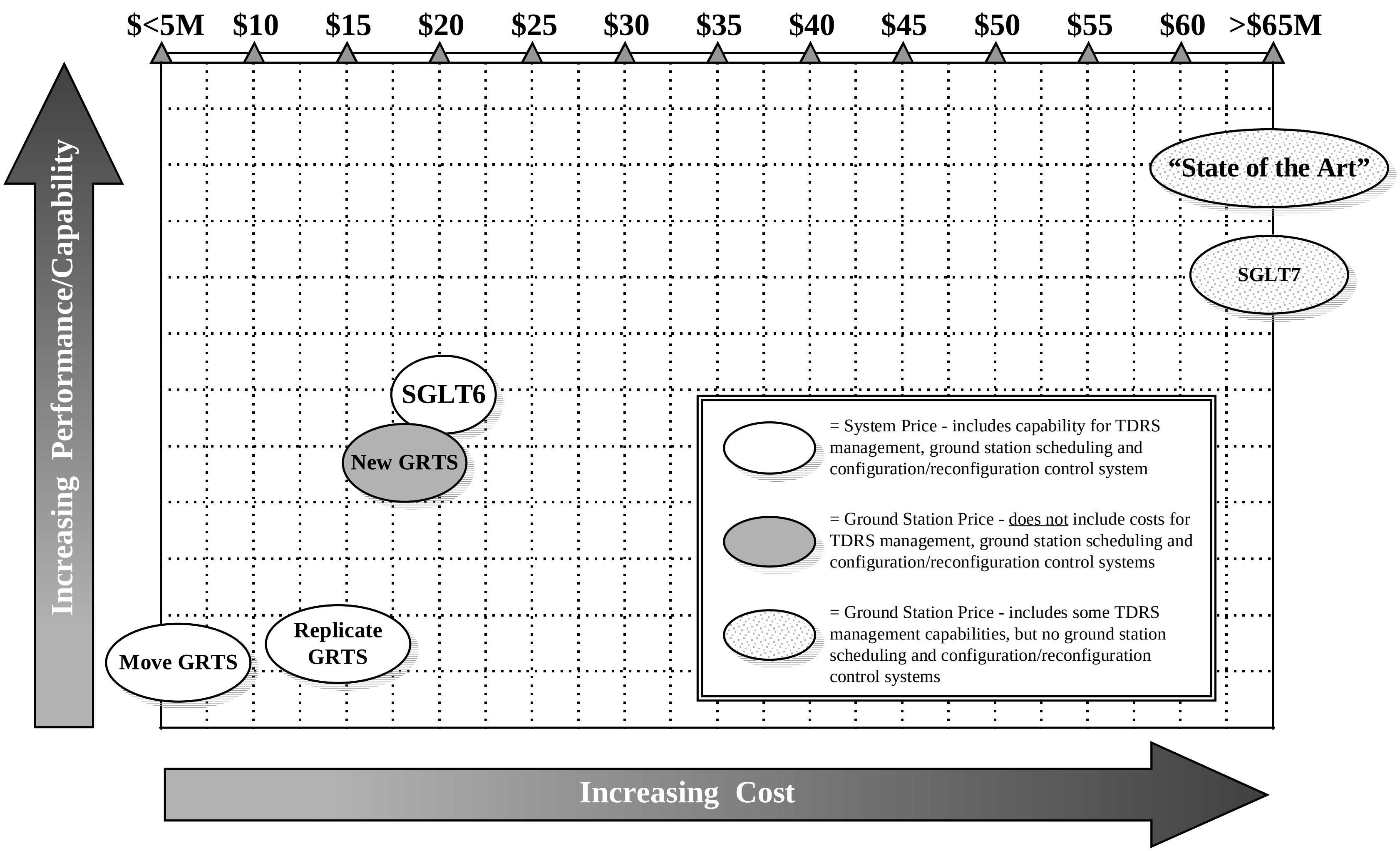
1. System operational availability is estimated. For systems with redundancy, the availability of a service (i.e. either the prime or redundant equipment is available) is estimated. The result is normalized to the WSC specification ($A_o \geq 0.9999$). The antenna system (which is NOT redundant in any approach) is not considered. This metric is weighted at 80%.

2. Relative ease of operation is an engineering/operations estimate of the degree to which human intervention is required to schedule, configure, operate and maintain the system. More human intervention raises the likelihood of human error (i.e. causing ETOs, schedule errors, vector errors, etc.). Values range from "significant intervention" (value = 10) to "no intervention" (value = 1). This metric is weighted at 20%.

Reliability Definition

Reliability is derived by an engineering estimate of the *inherent reliability* of a service. If a system has redundancy, the inherent availability is the availability of the prime and redundant equipment. The value is normalized to a derived "SGLT6 at Guam" value of 99.9%.

Cost/Performance Summary



Conclusions

- Cost Conclusions:
  - Antenna and facility costs roughly equivalent across all approaches.
  - Equipment cost varies dramatically depending on system composition.
  - Data interface costs roughly equivalent across most approaches.
  - External element costs vary dramatically depending on approach.
  - Transport costs roughly equivalent across approaches ("you get what you pay for") and vary with external service capability requirements.

Conclusions

- Attempting to support multiple customers through TDRS at the Guam station ***without*** a highly automated system can and will introduce human error.
- NASA (and non-NASA) mission requirements evolve - this points to a need for a straightforward system capability for change to ensure lower life-cycle costs .
- Many costs are suffered regardless of approach (i.e., facilities, antenna/IFL, data communications).
- External impacts of different architectures and ops concepts only touched on - more depth would be needed to accurately assess “total system” costs.

Study Participants

Thanks to:

- Jim Barker, Skip Rutemiller, Matt Griffin, Rich LaFontaine, James Brase, Roger Clason, Frank Stocklin, Dean Patterson, Don Smith, Riley Elwood, Marjorie Bacon, Dan Hein, and everyone else who helped with this study.

Option Cost/Option Metrics
Detailed Data

System	**Cost**		Less GFE	Potential Cost	E	S	R
Replicate GRTS	$ 15,012,000	($0.5M contingency)	$ (3,257,300)	$ 11,754,700	39	86	95
New GRTS	$ 22,934,200	($1.0M contingency)	$ (2,720,000)	$ 20,214,200	88	97	99
SGLT-7	$ 77,220,200	($7.0M contingency)			89	100	100
Relocate GRTS	$ 3,663,000	($0.0M contingency)			39	85	95
New "State of the Art" Baseline Architecture (Option 2)	$ 66,895,371	($2.0M contingency)			74	100	100
New "State of the Art" Alternate Architecture (Option 2)	$ 66,702,641	($2.0M contingency)			74	100	100
SGLT-6	$ 20,000,000				100	100	100

Replicate GRTS						
Item	Description	Qty	Cost Each	Total	Subtotals	Notes
MA Cal	10W Amp	2	$ 10,000	$ 20,000		serial vs. GPIB
	0.6W Antenna	1	$ 5,000	$ 5,000		
				$ 25,000	$ 25,000	
CTFS	System	1	$ 400,000	$ 400,000	$ 400,000	redundant system
USS	Ku-band to S-band downconveter	2	$ 40,000	$ 80,000		
	TURFTS (2 RF chassis, common controller, spares	1	$ 700,000	$ 700,000		
	MABE	1	$ 1,600,000	$ 1,600,000		**GFE from GRTS/Available**
	GIP PC	1	$ 75,000	$ 75,000		**GFE from GRTS/Available**
	User Service Processor	1	$ 20,000	$ 20,000		
	S-band to K-band Upconverter	2	$ 40,000	$ 80,000		
				$ 2,555,000	$ 2,555,000	
TTC	S-band to 450MHz downconveter	2	$ 30,000	$ 60,000		**Potential for GFE/May be Available**
	Multicoupler	2	$ 1,000	$ 2,000		
	MFR	2	$ 250,000	$ 500,000		**Potential for GFE/May be Available**
	PSK Demod	2	$ 18,000	$ 36,000		
	Bit Synch	2	$ 24,000	$ 48,000		
	Baseband Switch	1	$ 20,000	$ 20,000		
	TT&C Processor	1	$ 20,000	$ 20,000		
	GN Ranging equipment (1 RE/ 2 MFR)	1	$ 700,000	$ 700,000		**Potential for GFE/May be Available**
	RER Switch	1	$ 5,000	$ 5,000		**Potential for GFE/May be Available**
	RER Master Controller (DEC 112X)	1	$ 15,000	$ 15,000		**Potential for GFE/May be Available**
	REDX Computer	1	$ 5,000	$ 5,000		
	LA-100 Terminal	1	$ 1,000	$ 1,000		
	Cmd Validation Unit	2	$ 7,000	$ 14,000		
	PSK Command modulator	2	$ 4,000	$ 8,000		
	Command modulation A/B switch	1	$ 2,000	$ 2,000		
	TSS2000 Signal Generator	2	$ 48,000	$ 96,000		previously the S-band exciter
	4-way divider	2	$ 1,000	$ 2,000		
	TSS2000 Signal Generator	2	$ 48,000	$ 96,000		previously the Pilot generator (HP)
	TSS2000 Signal Generator	2	$ 48,000	$ 96,000		previously the Microwave source (HP)
	Time Code Reader	2		$ -		
	PCM Simulator	1	$ 30,000	$ 30,000		
	Fireberd 6000 Test Set	1	$ 11,400	$ 11,400		
	Metrotel Audio Test Set	1	$ 2,100	$ 2,100		
				$ 1,769,500	$ 1,769,500	
Control System	OMCS Operator Workstation	5	$ 15,000	$ 75,000		**Potential for GFE/Available**
	OMCS Laser Printer	3	$ 1,500	$ 4,500		
	OMCS LAN Router	3	$ 1,500	$ 4,500		**Potential for GFE/Available**
	CD-ROM Drive	3	$ 300	$ 900		**Potential for GFE/Available**
	Tape Drive	3	$ 400	$ 1,200		**Potential for GFE/Available**
	I/O Controller chassis with VME boards	2	$ 350	$ 700		**Potential for GFE/Available**
	I/O PLC	1	$ 4,000	$ 4,000		
	TATE Software licenses	1	$ 25,000	$ 25,000		**Potential for GFE/Available**
				$ 115,800	$ 115,800	
GDIS	Communications Mux/Demux	1	$ 130,000	$ 130,000		
	Frequency Synthesizer (GDP 541)	2	$ 5,600	$ 11,200		
	76B BERT test set	1	$ 20,000	$ 20,000		
	Metrotel Audio Test Set	1	$ 2,100	$ 2,100		
	Discrete Transmission Unit	1	$ 30,000	$ 30,000		
	Mux/Demux Redesign effort (to add Shuttle)	1	$ 10,000	$ 10,000		
				$ 203,300	$ 203,300	
Ant/Ant Equip	Pedestal					**GFE from WSGT/Available**
	11-m S-band/Ku-band Reflector and Feed	1	$ 470,000	$ 470,000		Includes $ 20K Refurb
	Radome (including shipping/installation)	1	$ 350,000	$ 350,000		PDR
	Polarizer	1	$ 1,000	$ 1,000		
	ACU	1	$ 65,000	$ 65,000		PDR
	Tracking Receiver	1	$ 40,000	$ 40,000		
	Tracking Downconverter	1	$ 110,000	$ 110,000		
	Diplexer	1	$ 1,000	$ 1,000		
	Ku-band High Power Combiner	1	$ 50,000	$ 50,000		
	Transmit reject filter	1	$ 50,000	$ 50,000		
	S-band receive bandpass filter	1	$ 10,000	$ 10,000		
	S-band transmit bandpass filter	1	$ 10,000	$ 10,000		
	Ku-band HPA	3	$ 40,000	$ 120,000		**Potential for GFE/Available**
	RF Switch	5	$ 400	$ 2,000		
	High power RF Switch	3	$ 1,000	$ 3,000		
	S-band PA with harmonic filter	2	$ 142,500	$ 285,000		
	Ku-band LNA (+misc)	2	$ 20,000	$ 40,000		
	S-band LNA (+misc)	2	$ 15,000	$ 30,000		
				$ 1,637,000	$ 1,637,000	
IFL Equipment	Waveguide, switches, coax	1	$ 100,000	$ 100,000	$ 100,000	PDR (less overlap of combiners/div etc)
Test Equipment	Scopes, analyzers, carts, probes	1	$ 350,000	$ 350,000	$ 350,000	
Cabling and Misc Parts	Coax, underfloor W/G, fiber, trays, raceways, etc	1	$ 135,000	$ 135,000	$ 135,000	
Racks	Buy + refurb existing	1	$ 90,000	$ 90,000	$ 90,000	~^$6K/rack
Shuttle Forward Link	Modulator	1	$ 40,000	$ 40,000		**Potential for GFE/Available**
	PN Spread Spectrum Equipment	1	$ 25,000	$ 25,000		**Potential for GFE/Available**
	Doppler PLC and PAL card	1	$ 20,000	$ 20,000		
	Microdyne MR700 Receiver	1	$ 30,000	$ 30,000		

				$ 115,000	$ 115,000	
Facilities	Demolition	1	$ 65,000	$ 65,000		Material and Labor
	Raised access floor	1	$ 335,000	$ 335,000		Material and Labor
	Interior Partitions	1	$ 59,000	$ 59,000		Material and Labor
	Suspended Ceiling	1	$ 56,000	$ 56,000		Material and Labor
	HVAC	1	$ 250,000	$ 250,000		Material and Labor (1/2 PDR cost)
	Fire Protection/Sprinklers	1	$ 80,000	$ 80,000		Material and Labor
	Grounding/Lightning protection	1	$ 50,000	$ 50,000		Material and Labor
	Interior Lighting	1	$ 85,000	$ 85,000		Material and Labor
	Parking Area	1	$ 100,000	$ 100,000		Material and Labor
	UPS and Batteries	1	$ 227,500	$ 227,500		Material and Labor (1/2 PDR cost)
	Switchgear	1	$ 170,000	$ 170,000		Material and Labor
	Distribution	1	$ 102,000	$ 102,000		Material and Labor
	4.5-m antenna foundation		$ -	$ -		Not needed for this option
	4.5-m cableway		$ -	$ -		Not needed for this option
	11-m antenna foundation	1	$ 300,000	$ 300,000		Material and Labor
	Radome entrance room	1	$ 300,000	$ 300,000		Material and Labor
				$ 2,179,500	$ 2,179,500	
Test Inject	Ku-band CW generator (HP)	1	$ 36,000	$ 36,000		
	TSS2000 Signal Generator	1	$ 48,000	$ 48,000		
	S-band test inject chassis	1	$ 8,000	$ 8,000		
	Translator	2	$ 5,000	$ 10,000		**Potential for GFE/May be available**
	Spectrum Analyzer (HP 8563A)	3	$ 40,000	$ 120,000		
	TURFTS Oscilloscope	1	$ 10,000	$ 10,000		
	OMCS Spectrum analyzer input switch	1	$ 4,200	$ 4,200		
	HP8648B signal generator	2	$ 7,700	$ 15,400		
	Ku-band translator	1	$ 12,000	$ 12,000		
	Test inject control chassis with PLC	1	$ 14,000	$ 14,000		
	Frequency Counter (HP 5350B)	1	$ 6,000	$ 6,000		
	Dual Channel Power Meter (HP438A) with sensors	3	$ 8,000	$ 24,000		
	Oscilloscope (TK2465B)	1	$ 9,000	$ 9,000		
	PLC (General Purpose)	2	$ 4,000	$ 8,000		
				$ 324,600	$ 324,600	
End -to-End Test System			$ -	$ -		No end-to-end test capability
Shuttle Unique (TV)			$ -	$ -		No TV capability
External Element Changes	new 224Kb line	1	$ 20,000	$ 20,000	$ 20,000	Reuse ETGT (no simo GRTS/GRGT ops)
Physical Security		1	$ 51,000	$ 51,000		PDR
Voice	Material and Labor	1	$ 86,300	$ 86,300		PDR
Development Labor	Includes Testing	1	$ 2,600,000	$ 2,600,000		
Training		0	$ -	$ -		No costs included (assumes no training necessary)
Initial Spares		1	$ 300,000	$ 300,000		
Shipping	Includes Ant ship	1	$ 150,000	$ 150,000		
Project Support	Sys eng, Logistics, plans,procs,etc	1	$ 1,000,000	$ 1,000,000		
Secure Systems	KG's/secure Muxes etc	1	$ 305,000	$ 305,000		PDR
Contingency		1	$ 500,000	$ 500,000		
				$ 4,992,300	$ 4,992,300	
Project Total					$ 15,012,000	
	less potential GFE				$ (3,257,300)	
	Potential Cost assuming GFE				$ 11,754,700	

New GRTS

Item	Description	Qty	Cost Each	Total	Subtotals	Notes
MA Cal	10W Amp	2	$ 10,000	$ 20,000		
	0.6W Antenna	1	$ 5,000	$ 5,000		
	370 MHz to S-band Upconveter	1	$ 40,000	$ 40,000		item needed since no TURFTS for sig gen
				$ 65,000	$ 65,000	
CTFS	System	1	$ 400,000	$ 400,000	$ 400,000	redundant system
USS	SSA1 Forward and Return Equipment					
	Ku- to IF Downconverter	1	$ 40,000	$ 40,000		
	Integrated Receiver	1	$ 150,000	$ 150,000		
	IF to Ku-band Upconverter	1	$ 40,000	$ 40,000		
	Modulator/Doppler Predictor	1	$ 100,000	$ 100,000		
	SSA2 Forward and Return Equipment					
	Ku- to IF Downconverter	1	$ 40,000	$ 40,000		
	Integrated Receiver	1	$ 150,000	$ 150,000		
	IF to Ku-band Upconverter	1	$ 40,000	$ 40,000		
	Modulator/Doppler Predictor	1	$ 100,000	$ 100,000		
	MAF and MA1/2 Return					
	Integrated Receiver	2	$ 150,000	$ 300,000		
	IF to Ku-band Upconverter	1	$ 40,000	$ 40,000		
	Modulator/Doppler Predictor	1	$ 100,000	$ 100,000		
	MABE	1	$ 1,600,000	$ 1,600,000		**GFE from GRTS/Available**
	GIP PC	1	$ 75,000	$ 75,000		
	KSA1 Forward and Return Equipment					
	Ku- to IF Downconverter	1	$ 40,000	$ 40,000		
	Integrated Receiver	1	$ 200,000	$ 200,000		
	High Data Rate Receiver	1	$ 1,000,000	$ 1,000,000		
	IF to Ku-band Upconverter	1	$ 40,000	$ 40,000		
	Modulator/Doppler Predictor	1	$ 100,000	$ 100,000		
	KSA2 Forward and Return Equipment					
	Ku- to IF Downconverter	1	$ 40,000	$ 40,000		
	Integrated Receiver	1	$ 200,000	$ 200,000		
	High Data Rate Receiver	1	$ 1,000,000	$ 1,000,000		
	IF to Ku-band Upconverter	1	$ 40,000	$ 40,000		
	Modulator/Doppler Predictor	1	$ 100,000	$ 100,000		
	Test Modem	1	$ 200,000	$ 200,000		
	Redundant Equipment					
	Ku- to IF Downconverter	1	$ 40,000	$ 40,000		
	IF to Ku-band Upconverter	1	$ 40,000	$ 40,000		
	SSA/KSA/MA IR	1	$ 200,000	$ 200,000		
	High Data Rate Receiver	1	$ 1,000,000	$ 1,000,000		
	Modulator/Doppler Predictor	1	$ 100,000	$ 100,000		
	Test Modem	1	$ 200,000	$ 200,000		
	Ku- to S-band Downconverter (2-channel)	2	$ 40,000	$ 80,000		
	S- to Ku-band Upconverter	1	$ 40,000	$ 40,000		
	Signal Generator (HP83711A)	1	$ 30,000	$ 30,000		
	BERT set	3	$ 20,000	$ 60,000		
	16x16 Baseband Switch	1	$ 20,000	$ 20,000		
	RF Switch (DPDT)	10	$ 400	$ 4,000		
	USP with S/W Development package	1	$ 20,000	$ 20,000		
	Control PLC	1	$ 25,000	$ 25,000		
				$ 7,594,000	$ 7,594,000	
TTC	S-band to 450 MHz Downconverter	2	$ 30,000	$ 60,000		**Potential for GFE/May be Available**
	Pilot Generator (TSS2000)	2	$ 48,000	$ 96,000		
	Signal Generator (TSS2000)	2	$ 48,000	$ 96,000		
	MFR's	2	$ 125,000	$ 250,000		**Potential for GFE/May be Available**
	RER Master Controller (DEC 112X)	1	$ 15,000	$ 15,000		**Potential for GFE/May be Available**
	RER Switch	1	$ 5,000	$ 5,000		**Potential for GFE/May be Available**
	Ranging Equipment	1	$ 450,000	$ 450,000		**Potential for GFE/May be Available**
	PSK Demod/Bit Synch	2	$ 25,000	$ 50,000		
	Splitter	2	$ 1,000	$ 2,000		
	PSK Command modulator	2	$ 40,000	$ 80,000		
	TT&C Processor with S/W Development	1	$ 20,000	$ 20,000		
				$ 1,124,000	$ 1,124,000	
Control System	Monitor and Control System (inc development)	1	$ 100,000	$ 100,000	$ 100,000	(PC based 5 systems for dev/ops)
GDIS	GDIS MDM	1	$ 1,071,000	$ 1,071,000	$ 1,071,000	from GRGT PDR
Ant/Ant Equip	Pedestal	1	$ -	$ -		**GFE from WSGT**
	11-m S-band/Ku-band Reflector and Feed	1	$ 470,000	$ 470,000		includes $20K refurb
	Radome (including shipping/installation)	1	$ 350,000	$ 350,000		PDR
	Polarizer	2	$ 1,000	$ 2,000		
	ACU	1	$ 65,000	$ 65,000		PDR
	Tracking Receiver	1	$ 40,000	$ 40,000		
	Tracking Downconverter	1	$ 110,000	$ 110,000		
	Diplexer	1	$ 1,000	$ 1,000		
	Ku-band High Power Combiner	1	$ 50,000	$ 50,000		
	Transmit reject filter	1	$ 50,000	$ 50,000		
	Harmonic Filter	1	$ 10,000	$ 10,000		
	S-band receive bandpass filter	1	$ 10,000	$ 10,000		
	S-band transmit bandpass filter	1	$ 10,000	$ 10,000		
	Ku-band HPA (want 14 if GFE for full redundancy)	8	$ 40,000	$ 320,000		**Potential for GFE/Available**
	RF Switch	12	$ 400	$ 4,800		
	High power RF Switch	7	$ 1,000	$ 7,000		
	S-band PA	2	$ 55,000	$ 110,000		
	Ku-band LNA (+misc)	2	$ 20,000	$ 40,000		
	S-band LNA (+misc)	2	$ 15,000	$ 30,000		
	Divider	1	$ 1,000	$ 1,000		
	Splitter	2	$ 1,000	$ 2,000		
				$ 1,682,800	$ 1,682,800	
IFL Equipment	Waveguide, switches, coax	1	$ 100,000	$ 100,000	$ 100,000	PDR (less overlap of combiners/div etc)
Test Equipment	Scopes, analyzers, carts, probes	1	$ 500,000	$ 500,000	$ 500,000	
Cabling and Misc Parts	Test Inject Misc	1	$ 10,000	$ 10,000		
	USS Misc	1	$ 360,000	$ 360,000		
	TTC Misc	1	$ 25,000	$ 25,000		
	Antenna Misc	1	$ 75,000	$ 75,000		
				$ 470,000	$ 470,000	
Racks	Buy + refurb existing	1	$ 270,000	$ 270,000	$ 270,000	~$6K/rack

Shuttle Forward Link		0	$ -	$ -		Included in USS
Facilities	Demolition	1	$ 65,000	$ 65,000		Material and Labor
	Raised access floor	1	$ 335,000	$ 335,000		Material and Labor
	Interior Partitions	1	$ 59,000	$ 59,000		Material and Labor
	Suspended Ceiling	1	$ 56,000	$ 56,000		Material and Labor
	HVAC	1	$ 510,000	$ 510,000		Material and Labor
	Fire Protection/Sprinklers	1	$ 80,000	$ 80,000		Material and Labor
	Grounding/Lightning protection	1	$ 50,000	$ 50,000		Material and Labor
	Interior Lighting	1	$ 85,000	$ 85,000		Material and Labor
	Parking Area	1	$ 100,000	$ 100,000		Material and Labor
	UPS and Batteries	1	$ 455,000	$ 455,000		Material and Labor
	Switchgear	1	$ 170,000	$ 170,000		Material and Labor
	Distribution	1	$ 102,000	$ 102,000		Material and Labor
	4.5-m antenna foundation		$ -	$ -		Not needed for this option
	4.5-m cableway		$ -	$ -		Not needed for this option
	11-m antenna foundation	1	$ 300,000	$ 300,000		Material and Labor
	Radome entrance room	1	$ 300,000	$ 300,000		Material and Labor
				$ 2,667,000	$ 2,667,000	
Test Inject	Ku-directional coupler	1	$ 2,000	$ 2,000		
	Ku translator	1	$ 12,000	$ 12,000		
	Ku signal generator (HP83732A)	1	$ 34,000	$ 34,000		
	Ku cabling, connectors, switches	1	$ 5,000	$ 5,000		
	Ku zeroset antenna	1	$ 2,000	$ 2,000		
	S band directional coupler	1	$ 1,000	$ 1,000		
	S band translator	2	$ 10,000	$ 20,000		**Potential for GFE/May be available**
	S band signal generator (TSS2000)	1	$ 48,000	$ 48,000		
	S band translator LO sig gen (HP864xx)	1	$ 7,700	$ 7,700		
	S band test inject	1	$ 8,000	$ 8,000		
	S band cabling, connectors, switches	1	$ 3,000	$ 3,000		
	S band zeroset antenna	1	$ 1,400	$ 1,400		
	Test inject controller	1	$ 14,000	$ 14,000		
				$ 158,100	$ 158,100	
d -to-End Test System			$ -	$ -		No end-to-end test capability
Shuttle Unique (TV)		1	$ 340,000	$ 340,000	$ 340,000	
ernal Element Changes		1	$ -	$ -	$ -	Not costed
Physical Security		1	$ 51,000	$ 51,000		PDR
Voice	Material and Labor	1	$ 86,300	$ 86,300		PDR
Development Labor	Includes testing	1	$ 3,200,000	$ 3,200,000		
Training	Operations personnel (11 out of 14) people	1	$ 100,000	$ 100,000		
Initial Spares		1	$ 500,000	$ 500,000		
Shipping	Includes Ant ship	1	$ 150,000	$ 150,000		
Project Support	Sys eng, Logistics, plans,procs,etc	1	$ 1,000,000	$ 1,000,000		
Secure Systems	KG's/secure Muxes etc	1	$ 305,000	$ 305,000		PDR
Contingency		1	$ 1,000,000	$ 1,000,000		
				$ 6,392,300	$ 6,392,300	
Total					$ 22,934,200	
	less potential GFE				$ (2,720,000)	
	Potential Cost assuming GFE				$ 20,214,200	

SGLT-7

Item	Description	Qty	Cost Each	Total	Subtotals	Notes
MA Cal			$ -	$ -	$ -	Included in USS MA costs
CTFS	System	1	$ 396,000	$ 396,000	$ 396,000	Material and Labor
USS	System	1	$ 25,241,800	$ 25,241,800	$ 25,241,800	Material and Labor
TTC	System	1	$ 6,490,800	$ 6,490,800	$ 6,490,800	Material and Labor
Control System	ADPE	1	$ 25,963,000	$ 25,963,000	$ 25,963,000	Material and Labor
GDIS	GDIS MDM	1	$ 1,537,000	$ 1,537,000	$ 1,537,000	Material and Labor
Ant/Ant Equip	Pedestal	1	$ -	$ -		**GFE from WSGT**
	11-m S-band/Ku-band Reflector and Feed	1	$ 445,000	$ 445,000		Includes $20K refurb (PDR)
	Radome (including shipping/installation)	1	$ 357,000	$ 357,000		PDR
	TIW ACU	1	$ 175,000	$ 175,000		
	Cables	1	$ 25,000	$ 25,000		
				$ 1,002,000	$ 1,002,000	
SMTF			$ -	$ -	$ -	
IFL Equipment	Waveguide, switches, coax	1	$ 200,000	$ 200,000	$ 200,000	PDR
Test Equipment	Scopes, analyzers, carts, probes	1	$ 700,000	$ 700,000	$ 700,000	
Cabling and Misc Parts			$ -	$ -	$ -	Included in subsystem estimates
Racks			$ -	$ -	$ -	Included in subsystem estimates
Shuttle Forward Link			$ -	$ -	$ -	Included in USS
Facilities	Demolition	1	$ 65,000	$ 65,000		Material and Labor
	Raised access floor	1	$ 335,000	$ 335,000		Material and Labor
	Interior Partitions	1	$ 59,000	$ 59,000		Material and Labor
	Suspended Ceiling	1	$ 56,000	$ 56,000		Material and Labor
	HVAC	1	$ 510,000	$ 510,000		Material and Labor
	Fire Protection/Sprinklers	1	$ 80,000	$ 80,000		Material and Labor
	Grounding/Lightning protection	1	$ 50,000	$ 50,000		Material and Labor
	Interior Lighting	1	$ 85,000	$ 85,000		Material and Labor
	Parking Area	1	$ 100,000	$ 100,000		Material and Labor
	UPS and Batteries	1	$ 455,000	$ 455,000		Material and Labor
	Switchgear	1	$ 170,000	$ 170,000		Material and Labor
	Distribution	1	$ 102,000	$ 102,000		Material and Labor
	4.5-m antenna foundation	1	$ 155,000	$ 155,000		Material and Labor
	4.5-m cableway	1	$ 100,000	$ 100,000		Material and Labor
	11-m antenna foundation	1	$ 300,000	$ 300,000		Material and Labor
	Radome entrance room	1	$ 300,000	$ 300,000		Material and Labor
				$ 2,922,000	$ 2,922,000	PDR
Test Inject			$ -	$ -	$ -	Function included in subsystems
End -to-End Test System	4.5m Ant Radome (inc. shipping/install.)	1	$ 156,000	$ 156,000	$ 156,000	Rack/antenna included in USS
Shuttle Unique (TV)		1	$ 297,000	$ 297,000	$ 297,000	PDR
External Element Changes		1	$ -	$ -	$ -	Not costed
Physical Security		1	$ 51,000	$ 51,000		PDR
Voice	Material and Labor	1	$ 86,300	$ 86,300		PDR
Development Labor	Development & Testing		$ -	$ -		Included in Subystem Costs
Training	14 people	1	$ 700,000	$ 700,000		
Initial Spares		1	$ 2,000,000	$ 2,000,000		
Shipping	Includes Antenna shipping	1	$ 150,000	$ 150,000		
Project Support	Sys Eng, Logistics, Plans, Procs, etc.	1	$ 2,000,000	$ 2,000,000		
Secure Systems	KG's/secure Muxes, etc.	1	$ 305,000	$ 305,000		PDR
Contingency		1	$ 7,022,300	$ 7,022,300		10% of Total Cost
				$ 12,314,600	$ 12,314,600	
Total					$ 77,220,200	
	less potential GFE				$ -	
	Potential Cost assuming GFE				$ 77,220,200	

Relocate GRTS				
Item	Description	Qty	Cost Each	
Ant/Ant Equip	11-m antenna Labor	1	$ 191,000	
	Material (including Radome)	1	$ 947,000	
IFL Equipment	Waveguide, switches, coax	1	$ 100,000	
Facilities		1	$ 1,500,000	
External Element Changes	NASCOM reconfig/subst 224Kb line	1	$ 4,000	
Site Unique Rengineering	5 pers/1mo.	1	$ 50,000	
Physical Security		1	$ 51,000	
Voice	Material and Labor	1	$ 86,000	
Development Labor	Deinstall/Reinstall (15 pers/3 mos.)	1	$ 262,000	
Testing	(15 pers/1 mo)	1	$ 87,000	
Shipping		1	$ 80,000	
Secure Systems	KG's/secure Muxes etc	1	$ 305,000	
Contingency				
Total			$ 3,663,000	(low estimate - assumes 1.5M fac cost)
			$4,830,000	(high estimate - assumes 2.67M fac cost)

New "State of the Art" Baseline Architecture (Option 2)

Item	Description	Qty	Cost Each	Total	Subtotals	Notes
MA Cal		1	$ 80,000	$ 80,000	$ 80,000	
CTFS	System	1	$ 172,390	$ 172,390	$ 172,390	
USS	System	1	$18,733,811	$18,733,811	$18,733,811	
TTC	System	1	$ 3,183,000	$ 3,183,000	$ 3,183,000	
Control System		1	$29,938,864	$29,938,864	$29,938,864	
GDIS	ATM equipment	1	$ -	$ -	$ -	In control system/subsystems
Ant/Ant Equip	Pedestal	1	$ -	$ -		**GFE from WSGT**
	11-m S-band/Ku-band Reflector and Feed	1	$ 470,000	$ 470,000		includes $20K refurb
	Radome (including shipping/installation)	1	$ 350,000	$ 350,000		PDR
	Polarizer	2	$ 1,000	$ 2,000		
	TIW ACU	1	$ 175,000	$ 175,000		PDR
	Tracking Receiver	1	$ 40,000	$ 40,000		
	Tracking Downconverter	1	$ 110,000	$ 110,000		
	Diplexer	1	$ 1,000	$ 1,000		
	Ku-band High Power Combiner	1	$ 50,000	$ 50,000		
	Transmit reject filter	1	$ 50,000	$ 50,000		
	Harmonic Filter	1	$ 10,000	$ 10,000		
	S-band receive bandpass filter	1	$ 10,000	$ 10,000		
	S-band transmit bandpass filter	1	$ 10,000	$ 10,000		
	Ku-band HPA	0	$ 40,000	$ -		In USS system
	RF Switch	12	$ 400	$ 4,800		
	High power RF Switch	7	$ 1,000	$ 7,000		
	S-band PA	0	$ 55,000	$ -		In TTC system
	Ku-band LNA (+misc)	2	$ 20,000	$ 40,000		
	S-band LNA (+misc)	2	$ 15,000	$ 30,000		
	Divider	1	$ 1,000	$ 1,000		
	Splitter	2	$ 1,000	$ 2,000		
				$ 1,362,800	$ 1,362,800	
SMTF		1	$ 418,260	$ 418,260	$ 418,260	
IFL Equipment	Waveguide, switches, coax	1	$ 100,000	$ 100,000	$ 100,000	PDR
Test Equipment	Scopes, analyzers, carts, probes	1	$ 571,245	$ 571,245	$ 571,245	
Cabling and Misc Parts			$ -	$ -	$ -	Included in subsystem estimates
Racks			$ -	$ -	$ -	Included in subsystem estimates
Shuttle Forward Link			$ -	$ -	$ -	Included in USS
Facilities	Demolition	1	$ 65,000	$ 65,000		Material and Labor
	Raised access floor	1	$ 335,000	$ 335,000		Material and Labor
	Interior Partitions	1	$ 59,000	$ 59,000		Material and Labor
	Suspended Ceiling	1	$ 56,000	$ 56,000		Material and Labor
	HVAC	1	$ 510,000	$ 510,000		Material and Labor
	Fire Protection/Sprinklers	1	$ 80,000	$ 80,000		Material and Labor
	Grounding/Lightning protection	1	$ 50,000	$ 50,000		Material and Labor
	Interior Lighting	1	$ 85,000	$ 85,000		Material and Labor
	Parking Area	1	$ 100,000	$ 100,000		Material and Labor
	UPS and Batteries	1	$ 455,000	$ 455,000		Material and Labor
	Switchgear	1	$ 170,000	$ 170,000		Material and Labor
	Distribution	1	$ 102,000	$ 102,000		Material and Labor
	4.5-m antenna foundation		$ -	$ -		Not needed for this option
	4.5-m cableway		$ -	$ -		Not needed for this option
	11-m antenna foundation	1	$ 300,000	$ 300,000		Material and Labor
	Radome entrance room	1	$ 300,000	$ 300,000		Material and Labor
				$ 2,667,000	$ 2,667,000	
Test Inject			$ -	$ -	$ -	Function included in subsystems
End -to-End Test System			$ -	$ -	$ -	Function included in subsystems
Shuttle Unique (TV)			$ -	$ -	$ -	Function included in subsystems
External Element Changes		1	$ -	$ -	$ -	Not Costed
Physical Security		1	$ 51,000	$ 51,000		PDR
Voice	Material and Labor	1	$ 86,300	$ 86,300		PDR
Development Labor	L2-4 Integration and testing only	1	$ 2,807,701	$ 2,807,701		Dev labor Included in subsystems
Training	14 people	1	$ 668,000	$ 668,000		
Initial Spares		1	$ 1,000,000	$ 1,000,000		
Shipping	Includes Ant ship	1	$ 750,000	$ 750,000		
Project Support	Sys eng, Logistics, plans,procs,etc	1	$ 2,000,000	$ 2,000,000		
Secure Systems	KG's/secure Muxes etc	1	$ 305,000	$ 305,000		PDR
Contingency		1	$ 2,000,000	$ 2,000,000		
				$ 9,668,001	$ 9,668,001	
Total					$66,895,371	
	less potential GFE				$ -	
	Potential Cost assuming GFE				$66,895,371	

New "State of the Art" Alternate Architecture (Option 2)

Item	Description	Qty	Cost Each	Total	Subtotals	Notes
MA Cal		1	$ 80,000	$ 80,000	$ 80,000	
CTFS	System	1	$ 172,390	$ 172,390	$ 172,390	
USS	System	1	$23,389,001	$23,389,001	$23,389,001	
TTC	System	1	$ 3,151,706	$ 3,151,706	$ 3,151,706	
Control System		1	$25,138,864	$25,138,864	$25,138,864	
GDIS	ATM equipment	1	$ -	$ -	$ -	In control system/subsystems
Ant/Ant Equip	Pedestal	1	$ -	$ -		**GFE from WSGT**
	11-m S-band/Ku-band Reflector and Feed	1	$ 470,000	$ 470,000		includes $20K refurb
	Radome (including shipping/installation)	1	$ 350,000	$ 350,000		PDR
	Polarizer	2	$ 1,000	$ 2,000		
	TIW ACU	1	$ 175,000	$ 175,000		PDR
	Tracking Receiver	1	$ 40,000	$ 40,000		
	Tracking Downconverter	1	$ 110,000	$ 110,000		
	Diplexer	1	$ 1,000	$ 1,000		
	Ku-band High Power Combiner	1	$ 50,000	$ 50,000		
	Transmit reject filter	1	$ 50,000	$ 50,000		
	Harmonic Filter	1	$ 10,000	$ 10,000		
	S-band receive bandpass filter	1	$ 10,000	$ 10,000		
	S-band transmit bandpass filter	1	$ 10,000	$ 10,000		
	Ku-band HPA	0	$ 40,000	$ -		In USS system
	RF Switch	12	$ 400	$ 4,800		
	High power RF Switch	7	$ 1,000	$ 7,000		
	S-band PA	0	$ 55,000	$ -		In TTC system
	Ku-band LNA (+misc)	2	$ 20,000	$ 40,000		
	S-band LNA (+misc)	2	$ 15,000	$ 30,000		
	Divider	1	$ 1,000	$ 1,000		
	Splitter	2	$ 1,000	$ 2,000		
				$ 1,362,800	$ 1,362,800	
SMTF		1	$ 418,260	$ 418,260	$ 418,260	
IFL Equipment	Waveguide, switches, coax	1	$ 100,000	$ 100,000	$ 100,000	PDR
Test Equipment	Scopes, analyzers, carts, probes	1	$ 571,245	$ 571,245	$ 571,245	
Cabling and Misc Parts			$ -	$ -	$ -	Included in subsystem estimates
Racks			$ -	$ -	$ -	Included in subsystem estimates
Shuttle Forward Link			$ -	$ -	$ -	Included in USS
Facilities	Demolition	1	$ 65,000	$ 65,000		Material and Labor
	Raised access floor	1	$ 335,000	$ 335,000		Material and Labor
	Interior Partitions	1	$ 59,000	$ 59,000		Material and Labor
	Suspended Ceiling	1	$ 56,000	$ 56,000		Material and Labor
	HVAC	1	$ 510,000	$ 510,000		Material and Labor
	Fire Protection/Sprinklers	1	$ 80,000	$ 80,000		Material and Labor
	Grounding/Lightning protection	1	$ 50,000	$ 50,000		Material and Labor
	Interior Lighting	1	$ 85,000	$ 85,000		Material and Labor
	Parking Area	1	$ 100,000	$ 100,000		Material and Labor
	UPS and Batteries	1	$ 455,000	$ 455,000		Material and Labor
	Switchgear	1	$ 170,000	$ 170,000		Material and Labor
	Distribution	1	$ 102,000	$ 102,000		Material and Labor
	4.5-m antenna foundation		$ -	$ -		Not needed for this option
	4.5-m cableway		$ -	$ -		Not needed for this option
	11-m antenna foundation	1	$ 300,000	$ 300,000		Material and Labor
	Radome entrance room	1	$ 300,000	$ 300,000		Material and Labor
				$ 2,667,000	$ 2,667,000	
Test Inject			$ -	$ -	$ -	Function included in subsystems
d -to-End Test System			$ -	$ -	$ -	Function included in subsystems
Shuttle Unique (TV)			$ -	$ -	$ -	Function included in subsystems
ernal Element Changes		1	$ -	$ -	$ -	Not costed
Physical Security		1	$ 51,000	$ 51,000		PDR
Voice	Material and Labor	1	$ 86,300	$ 86,300		PDR
Development Labor	L2-4 Integration and testing only	1	$ 2,791,075	$ 2,791,075		Dev labor Included in subsystems
Training	14 people	1	$ 668,000	$ 668,000		
Initial Spares		1	$ 1,000,000	$ 1,000,000		
Shipping	Includes Ant ship	1	$ 750,000	$ 750,000		
Project Support	Sys eng, Logistics, plans,procs,etc	1	$ 2,000,000	$ 2,000,000		
Secure Systems	KG's/secure Muxes etc	1	$ 305,000	$ 305,000		PDR
Contingency		1	$ 2,000,000	$ 2,000,000		
				$ 9,651,375	$ 9,651,375	
Total					$66,702,641	
	less potential GFE				$ -	
	Potential Cost assuming GFE				$66,702,641	

System	Service Capability								Total	Reimbursement		Services per	Logistics	Logistics
	SSAF	SSAR	KSAF	KSAR	MAF	MAR	STRK	KTRK	Services	Potential	Staff	Staff	Cost/year	Complexity
Replicate GRTS	1	1	0	0	0	2	0	0	4	$278	14	0.29	$285,000	1.25
New GRTS	2	2	2	2	2	2	2	2	16	$1,154	17	0.94	$300,000	1.25
SGLT7	2	2	2	2	2	2	2	2	16	$1,154	14	1.14	$375,000	2
Move GRTS	1	1	0	0	0	2	0	0	4	$278	14	0.29	$285,000	1.25
New "State of the Art" Baseline	2	2	2	2	2	2	2	2	16	$1,154	20	0.80	$400,000	1.5
New "State of the Art" Alternate	2	2	2	2	2	2	2	2	16	$1,154	20	0.80	$400,000	1.5
SGLT6	2	2	2	2	2	2	2	2	16	$1,154	14	1.14	$350,000	1

System	(Svc/staff)/ SGLT6 Base	Weight	SGLT6 Base/ Log Cost x Complexity	Weight	Reimb/ SGLT6 Base	Weight	Metric Value
Replicate GRTS	0.25		0.98		0.24		39
New GRTS	0.82		0.93		1.00		88
SGLT7	1.00		0.47		1.00		89
Move GRTS	0.25		0.98		0.24		39
New "State of the Art" Baseline	0.70		0.58		1.00		74
New "State of the Art" Alternate	0.70		0.58		1.00		74
SGLT6	1.00	0.60	1.00	0.20	1.00	0.20	100

S Calculations

System	System Operational Availability	Schedule	Configure	Operate	Maintain	Ease of Operation (S+C+O+M)	Redundancy/ Availability/ SGLT6 Base	Weight
Replicate GRTS	0.99	8	4	4	2	18	0.9901	
New GRTS	0.999	2	1	2	2	7	0.9991	
SGLT7	0.9999	1	1	2	2	6	1.0000	
Move GRTS	0.98	9	4	4	2	19	0.9801	
New "State of the Art" Alternate	0.9984	1	1	2	2	6	0.9985	
New "State of the Art" Baseline	0.9994	1	1	2	2	6	0.9995	
SGLT6	0.9999	1	1	2	2	6	1.0000	0.80

(antenna system not considered in availability)

System	SGLT6 Base Ease of Operation/	Weight	Metric Value
Replicate GRTS	0.33		86
New GRTS	0.86		97
SGLT7	1.00		100
Move GRTS	0.32		85
New "State of the Art" Alternate	1.00		100
New "State of the Art" Baseline	1.00		100
SGLT6	1.00	0.20	100

(antenna system not considered in availabi

System	System Inherent Reliability	Reliability/ SGLT6 Base	Metric Value
Replicate GRTS	0.95	0.9510	95
New GRTS	0.99	0.9910	99
SGLT7	0.999	1.0000	100
Move GRTS	0.95	0.9510	95
New "State of the Art" Baseline	0.999	1.0000	100
New "State of the Art" Alternate	0.999	1.0000	100
SGLT6	0.999	1.0000	100

(antenna system not considered in reliability)